DOCUMENT RESUME

ED 335 367 TM 016 962

AUTHOR	Burstein, Leigh; And Others
TITLE	Models for Validating Content Coverage. Instructional Assessment Project.
INSTITUTION	Center for Research on Evaluation, Standards, and Student Testing, Los Angeles, CA.
SPONS AGENCY	Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE	Feb 91
CONTRACT	OERI-G-86-0003
NOTE	64p.
PUB TYPE	Collected Works - General (020) -- Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Academic Achievement; Content Analysis; *Content Validity; *Curriculum Evaluation; *Educational Assessment; Elementary Secondary Education; Evaluation Methods; Mathematics Teachers; Mathematics Tests; *Models; Psychometrics; Research Reports; Student Evaluation; Teacher Attitudes; Teacher Role
IDENTIFIERS	*Instructionally Sensitive Assessment (Burstein)

ABSTRACT

Two papers are presented that resulted from the Instructional Assessment Project of the Center for Research on Evaluation, Standards, and Student Testing. Both relate to models for assuring assessment validity. The first paper--"Assessing the Content Validity of Teachers' Reports of Content Coverage and Its Relationship to Student Achievement" by B. Yoon and others--studied the validity of teachers' reports of students' instructional experiences by examining the reported content coverage for teachers across two consecutive years (1988 and 1989). It also examined the sensitivity of tests to instruction by linking student performance patterns to students' instructional experiences. Analyses were based on data from approximately 300 mathematics class sections, with about 2,000 students (examinees) and 20 teachers for each of 2 tests for each year. The second paper--"Conceptual Considerations in Instructionally Sensitive Assessment" by L. Burstein--describes the project's operating model, with its intellectual rationale and the guiding concept of instructionally sensitive psychometrics. Implications for the application of the methodology to other large-scale achievement contexts are discussed. Three figures and 3 appendices with 9 tables are included. (SLD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

C·R·E·S·S·T

Center for Research on Evaluation, Standards, and Student Testing

TM

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

J. C. BEER

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Center for Research on Evaluation,
Standards, and Student Testing

Final Deliverable - February 1991

Instructional Assessment Project

Models for Validating Content Coverage

TM016962

BEST COPY AVAILABLE

TM

Center for Research on Evaluation,
Standards, and Student Testing

Final Deliverable - February 1991

Instructional Assessment Project

Models for Validating Content Coverage

Project Director: Leigh Burstein

Research Assistants: Bokhee Yoon and Karen Gold

Grant Number: OERI-G-86-0003

Center for the Study of Evaluation
Graduate School of Education
University of California, Los Angeles

The research reported herein was conducted with partial support from the U.S. Department of Education, Office of Educational Research and Improvement, pursuant to Grant No. G0086-003. However, the opinions expressed do not necessarily reflect the position or policy of this agency and no official endorsement by the agency should be inferred.

Preface

This document presents two papers resulting from the Instructional Assessment project, both related to models for assuring assessment validity. The first, Assessing the Content Validity of Teachers' Reports of Content Coverage and Its Relationship to Student Achievement, investigates the validity of teachers' reports of students' instructional experiences by examining the consistency of reported content coverage for teachers across two consecutive years. It furthermore examines the sensitivity of tests to instruction by linking student performance patterns to students' instructional experiences.

The second paper, Conceptual Considerations in Instructionally Sensitive Assessment, describes the project's operating model. Both the intellectual rationale for the project and current version of the guiding conception of "instructionally sensitive psychometrics" are discussed. The paper also considers practical realities derived from our experiences in analyzing SIMS data thus far and possible implications for applying our methodology in other large scale achievement contexts.

Assessing the Content Validity of Teachers' Reports of Content Coverage and Its Relationship to Student Achievement

Bokhee Yoon
Leigh Burstein
Karen Gold

Many conceptual and analytical studies have been conducted to improve the validity of subject matter tests and the instructional sensitivity of psychometric and statistical methods used to analyze, interpret, and report test data in a large-scale achievement testing (Burstein, 1989, 1990; Muthén, Kao, & Burstein,1988; Burstein, Aschbacher, Chen, Linn, & Sen, 1986; Cole, 1988; Linn, 1983, 1987, 1989; Muthén, 1989; Gold, 1990; Harnisch, 1983; Schmidt, 1983; Porter, 1989). Generally, there are multiple, systematic factors that contribute to student performance as measured by an instructional assessment at a given point in time. The factors, such as student ability, topic exposure, and methods of instructional exposure, that affect performance have to be considered in designing, analyzing and reporting tests (Burstein, 1990; Burstein, et al., 1987; Yoon, Burstein, Gold, Chen, & Kim, 1990; Muthén, Kao & Burstein, 1987; Leinhardt & Seewald, 1981; Leinhardt, 1983).

As achievement tests have become influential in policy decisions, the degree of overlap between the content tested and the content taught has increased in importance (Airasian & Madaus, 1983; Leinhardt & Seewald, 1981). Students' exposure to different subject matter, and the way in which subject matter has been covered, will affect students' performance on tests. Therefore, how well achievement test items reflect both student knowledge and the content of instruction are clearly of interest (Harnisch & Linn, 1981). Content coverage is considered especially important in state-by-state comparisons with increased concern with fairness of the comparisons due to

differential learning opportunities across states or districts (Linn, 1983).

The purposes of the present study are (1) to investigate the validity of teachers' reports of students' instructional experiences (content exposure or coverage) by examining the consistency of reported content coverage for teachers across two consecutive years (1988 & 1989), and (2) to examine the sensitivity of tests to instruction by linking student performance patterns to instructional experiences of students as possible corroborating evidence of their relationship. The results of earlier attempts validating teachers' reports of content coverage were reported elsewhere (Yoon, et al., 1990). This study refined the procedures from the earlier work by looking at each teacher's report of content coverage and relating it to his/her students' performance on each item.

Data

The data used in this study came from the Mathematics Diagnostic Testing Program (MDTP). Under this project, the University of California and California State University systems have developed a series of four diagnostic tests (Algebra Readiness, Elementary Algebra, Intermediate Algebra, and Precalculus) to be used voluntarily in middle and secondary schools in California in an effort to improve secondary school mathematics. MDTP also offers teachers the opportunity to obtain student-level diagnostic performance data through the administration of one of a variety of examinations.

In this study, analyses are based on teacher and student data from approximately 300 sections (176 sections, 3 districts, 8 schools in 1988, and 112 sections, 3 districts, 10 schools in 1989) of mathematics spanning courses in Pre-Algebra, Math A, Math B (special to California schools as an alternative route to Algebra I), Algebra I, and Geometry. The analyses in this study are based on data from the Algebra Readiness and the Elementary Algebra examinations administered during the 1988 and 1989 school years. Each of these tests consists of fifty multiple-choice items administered during a fifty minute class period. There are approximately 2000 examinees and 20 teachers for both tests considered per year after matching by teacher and course for 1988 and 1989.

Instrumentation

In addition to the achievement data in the study, classroom teachers responded to a questionnaire about their coverage of mathematics topics presented in each of the classrooms that were administered the diagnostic test. The response options for each mathematics topic on the questionnaire were examined and patterns of teachers' responses on content coverage were evaluated and classified.

In our instrumentation, teachers were presented with different math topics and were asked to indicate how these topics were covered in each mathematics course they teach, using the following set of response options:

a. NEW -- Taught as New content
b. EXTENDED -- Reviewed and Extended
c. REVIEW -- Reviewed only
d. ASSUMED -- Assumed as prerequisite knowledge & neither taught nor reviewed
e. TAUGHT LATER -- Taught later in the school curriculum
f. NOT IN CURRICULUM -- Not in the school curriculum
g. DON'T KNOW -- Not taught now and don't know if in school curriculum

The seven response alternatives are adapted from Opportunity to Learn questions and topic-specific teacher questionnaires used in the Second International Mathematics Study[1]. The questionnaire included topics which were identified as included in any of the four tests developed by MDTP or in the secondary school mathematics grid developed as part of an earlier study of the content validity of MDTP tests (Burstein, et. al,1986). Thus the questionnaire was expected to span the course material for college-preparatory secondary school mathematics, necessitating an extensive list of topics (97 topics classified into 12 distinct subgroups): integers (4 topics); fractions, decimals, ratio, proportion, and percent (14); exponents, radicals, rational expression and square roots (14); polynomials (12); algebraic equations (11); inequalities (3); rational expressions (4); probability and statistics (2); geometry (15); absolute value (2); functions (10); and trigonometry (6).

If there was more than 80% consensus among teachers or each teacher across periods in a specific topic category (for a specific course), the topic was assigned one of the following

---

[1] These data are from national sample of United States 8th grade students mathematics achievement tests conducted by IEA (The International Association for the Evaluation of Educational Achievement) in 1981-1982.

categories: CORE (New + Extended), PRIOR (Reviewed + Assumed), NOT TAUGHT (Taught later + Not in curriculum + Don't know). These auxiliary data were used to validate the substantive interpretation of the multidimensional structure of the test and the effect of the differential learning on student performance indicated by the current analyses of the achievement data.

Methods and Techniques

The study relates patterns of teachers' content coverage responses with students' performance on the diagnostic math achievement tests. The first set of analyses with the teacher data involved investigating how consistently and how differently course topics have been covered across years and within the same year by each teacher. Teachers' content coverage for a specific course was analyzed by extending previous research (Yoon, et al., 1990) to look at content coverage by:

a) the same teacher teaching the same course across years in 1988 and 1989 results shown in Figure 1, Tables A-1 and A-2 in the Appendix A),

b) the same teacher teaching different courses in 1988 (Figure 2 and Table B-1 in the Appendix B) or,

c) the same teacher teaching different courses in 1989 (Figure 2 and Table B-2 in the Appendix B).

The same teacher teaching a different course in different years (i.e., teaching Algebra I in 1988 and Geometry in 1989 also was analyzed, but since the results showed a pattern similar to b) and c), those results will not be presented here.

Figure 1 shows the plot of topics with content coverage by courses for the same course and the same teacher for two consecutive years and the notations for the courses are: L (Lower than Pre-Algebra), M (Math A), P (Pre-Algebra), A (Algebra I) and G (Geometry). Figure 2 shows the plot of topics with content coverage by courses for the same teacher teaching different courses across two years and the notation for the courses are: PG (A teacher taught both Pre-Algebra and Geometry in the same year.), MA (Math A & Algebra I), LM (Lower than Pre-Algebra & Math A), MG (Math A & Geometry), and AG (Algebra I & Geometry).

Evidence that reported content coverage patterns are similar across years may suggest that the chosen means of collecting such data has functioned as expected under the "steady state" curricular conditions prevalent in participating schools. A representative sample of the results is shown in Tables A-1 to B-2 in Appendices A and B. The notations for these tables are as follow:

1.CC: Taught as CORE across years
2.PP: Taught as PRIOR across years
3.NN: NOT TAUGHT across years
4.CP: Taught as CORE in 1988 and as PRIOR in 1989
5.CN: Taught as CORE in 1988 and NOT TAUGHT in 1989
6.PC: Taught as PRIOR in 1988 and as CORE in 1989
7.PN: Taught as PRIOR in 1988 and NOT TAUGHT in 1989
8.NC: NOT TAUGHT in 1988 and taught as CORE in 1989
9.NP: NOT TAUGHT in 1988 and taught as PRIOR in 1989

The second set of analyses relates the teacher topic coverage response data to student performance at the item level. The differences in year 1 (1988) and year 2 (1989) p-values at

the item level were calculated and these differences were compared to differences in teachers' reported coverage of topics across the two years. These analyses show how consistently each teacher covered a course topic across years and, if they are not consistent, whether the lack of consistency systematically affects students' performance on MDTP test items measuring a given topic. Performance on test items in a given topic area should be consistent with teachers' reports of coverage of these topics. The MDTP Algebra Readiness and Elementary Algebra tests were considered here. Students enrolled in Lower than Pre-Algebra, Math A, Math B, or Pre-Algebra took the MDTP Algebra Readiness test, and students enrolled in Algebra I or Geometry took the Elementary Algebra test. The results pooled across the classes and teachers using Algebra Readiness Test and Elementary Algebra Test are shown in Figure 3 and the results for each are shown in Tables C-1 to C-5 in the Appendix C.

Results

Topic Coverage Patterns

The results in Figure 1 and Figure 2 provide evidence on the validity of teachers' responses on content coverage for a given course. The results of teacher content coverage by the same teacher teaching the same course across years (i.e., the same course taught by the same teacher in both 1988 and 1989) are summarized in Figure 1 which shows the plot of topics with content coverage by courses. (More detailed results including

item contents are presented in Tables A-1 and A-2 in the Appendix A.)

The results in Figure 1 show that 71% of topics were claimed to have been covered consistently in different levels of courses across two years. In the category of CC (taught as CORE both in 1988 and 1989), 30% of topics were covered as CORE consistently across courses in both years which implies that topics were mostly covered as new topics or reviewed and extended across courses. The number of topics considered as CORE in each course increased as the course level went up; in other words, about 20 topics were taught as CORE in Lower than Pre-Algebra while about 36 topics in Pre-Algebra, and about 40 topics in Algebra I were taught as CORE for two consecutive years. However, the number of topics taught as CORE in Geometry is relatively small (about 12 topics) which is reasonable because most topics taught as CORE in lower level courses were covered as PRIOR in Geometry. As shown in the category of PP, about 33 topics covered as PRIOR in Geometry while less than 10 topics were covered in Algebra I as PRIOR. There was only few topics were covered as PRIOR in Lower than Pre-Algebra and Pre-Algebra courses, as expected. In the category of NN, about 66 topics were not taught in Lower than Pre-Algebra and the number of topics covered as NOT TAUGHT went down considerably in Algebra I and in Geometry. The deviations in consistency in the categories of CP, CN, PC, PN, NC and NP may be due to either to changes in school or district curriculum policies or differences in class composition across years or inconsistent reporting.

These variations may also depend on the specificity and clarity of topic descriptions as well as on individual differences among teachers in their use of the response scale.

In Algebra I, with the exception of one teacher (T15; the detailed results are shown in Table A-2 in the Appendix A.), teachers covered topics for each course consistently across years. Topic coverage in Algebra I concentrates on the traditional core of introductory algebra (exponents, polynomials, algebraic equations, inequalities, rational expressions, absolute value). In Geometry, many more topics were covered as PRIOR compared to Algebra I and the number of topics covered as CORE across years decreased considerably from Algebra I to Geometry as shown in Figure 1. Topics such as "Pythagorean Theorem," "perimeter & area of triangles," "volume of cubes, cylinders," were covered as CORE; otherwise, topics covered as CORE in Algebra I were covered as PRIOR in Geometry. The idiosyncracy of plots in the categories of CP, CN, PN and PC in Algebra I and Geometry are because teacher T15 taught an "advanced" class in 1988 and a "typical" class in 1989. This implies that students' instructional experiences may be affected by class types.

Figure 2 shows the results of teachers' responses of content coverage across different courses for two consecutive years. The results including content coverage of 97 topics by the same teacher who taught different courses in 1988 or in 1989 are reported in Tables B-1 and B-2 in the Appendix B. These results show how the same topics were covered in both low (i.e.,

lower than Pre-Algebra) and high (i.e., Algebra I) levels of classes and how consistently a teacher covered topics in different courses across years. About 22 % of topics were covered as CORE across courses such as Math A and Algebra I, Lower than Pre-Algebra and Pre-Algebra, and Algebra I and Geometry. About 31% of topics were covered as NOT TAUGHT across courses which was the same as in Figure 1. These results support the results of consistency of content coverage across years in Figure 1. As expected, the categories of CP and NC showed a reasonable transition in content coverage across courses.

In the category of CP, there was a big transition on content coverage from Algebra I to Geometry. About 60 topics were covered consistently as CORE in Algebra I and as PRIOR in Geometry by the same teacher across years. In this category all the lower level courses were compared with higher courses which showed a logical expectation of content coverage across courses. Similarly, the category of NC shows that 19% of topics across courses were covered as NC and lower level courses compared with higher level courses.

The categories of CN, PC and PN clearly provide other evidence of validity of teachers' responses on content coverage by showing almost 0% of topic coverage in these categories across lower level and higher level courses. There was almost no topic covered as PRIOR in Math A and as CORE in Algebra I, or as PRIOR in Pre-Algebra and as CORE in Geometry. These results strongly support the validity of teachers' responses on content

coverage in a given course. Topics taught differently across courses are "finding sum of interior angles," "isosceles & equilateral triangles," and "congruent triangles," taught as CORE in Pre-Algebra, as PRIOR in Algebra I, but as NOT TAUGHT in Lower than Pre-Algebra.

Overall, the results above showed that the prevalence and type of coverage of topics were consistent with their curricular sequence across years. Patterns were consistent with logical expectations for the topic within a given course across years and across teachers; therefore, cross-validation of teachers' responses on content coverage in a specific topic category (for a specific course) was successful.

Relationships with Performance

The p-value differences between 1988 and 1989 at the item level for classes taught by the same teacher in successive years were related to differences in teachers' reported coverage of topics in Figure 3 and Tables C-1 to C-5 in the Appendix C. These results examine the coherence of reported coverage with actual performance patterns by analyzing what was taught at secondary school mathematics and what was tested. Furthermore, content coverage of test item topics were related with students' performance on Algebra Readiness Test and Elementary Algebra Test.

Content coverage reports of test item topics in Tables C-1 to C-5 in the Appendix C validated the content validity of test items in Algebra Readiness Test and Elementary Algebra Test by

showing a consistent content coverage on the test item topics. In other words, topics which were claimed to be taught were most likely tested in both tests and this validates the content validity of test items.

P-value difference distributions of students' performance on Algebra Readiness Test and Elementary Algebra Test are shown in Figure 3. When topics were taught consistently across years as in the category of CC, p-values do not typically vary across years, however, there were some deviations in p-values when topics were taught differently across years. For example, p-value mean difference of .04 when topics were covered as CORE and as PRIOR and .05 difference when topics were covered as NOT TAUGHT in 1988 and as CORE in 1989.

However, these results are not convincing since these p-value differences are the average p-value differences across topics. When p-value differences were considered for each topic, some topics were relatively more sensitive to content coverage than the other topics. For example, the topics "exponents with integral exponent," "order & comparison of fractions," and "computation of percent" showed relatively large p-value differences, greater than .20. These topics were taught as CORE in 1988 and as PRIOR in 1989. In Math A, the topics "simplification of a rational expression" and "multiplication & division of fractions" showed relatively large p-value differences greater than .13. These topics were also covered as CORE in 1988 and as PRIOR in 1989. These topics show effects of different content coverage on students' performance. In Pre-

Algebra, the topic "Location of points in coordinate plane" showed a p-value difference of .15 and it was covered as NOT TAUGHT in 1988 and as CORE in 1989. This topic was sensitive to the content coverage, which again clearly shows that exposure to a topic influences students' performance. The topics "basic operations with signed number" and "addition & subtraction of decimals" showed p-value differences but were not sensitive to content coverage. These relatively easy topics do not seem to get influenced as much as fairly hard topics do. The topic "Pythagorean Theorem & special triangle" also seems to be sensitive to content coverage showing a p-value difference of .12 topics covered as NOT TAUGHT in 1988 and as CORE in 1989. The topics "algebra operation of literal symbol," "circumference & area of circle," "addition & subtraction of square roots" and "solving quadratic equation by factoring" also showing an evidence of the effect of content coverage with very low p-values or p-value differences less than .10 topics covered as NOT TAUGHT. These results are shown in Tables C1 to C5 in the Appendix C.

Implication

We considered the validity of teachers' responses on students' instructional experiences (content coverage) and viewed student test performance as supporting evidence. The patterns of responses were potentially realistic portrayals of coverage for different courses and topics at certain levels of specificity. This study provided an insight into the

functioning of teachers' questionnaire responses about content coverage by examining and monitoring instructional practices.

Since the effect of content coverage is sensitive to the level of item difficulty, analyzing p-value differences as a function of the level of item difficulty, teachers' characteristics and content coverage might be interesting. Especially since teachers responded to the questionnaire without looking at the test items in this study, taking a consideration of item difficulty in an analysis would be worthwhile.

References

Airasian, P. & Madaus, G. (1983). Linking testing and instruction: Policy issues. *Journal of educational measurement*, 20(2), 103-117.

Anderson, L. W. (1990). *Opportunity to Learn (OTL) and the National Assessment of Educational Progress (NAEP): An Analysis with Recommendations.* Unpublished manuscript. Columbia, S.C.: University of South Carolina.

Berliner, D.C. (1980). Studying instruction in the elementary classroom. In R. Dreeben and J.A. Thomas (Eds.), *The Analysis of Educational Productivity: Vol. 1. Issues in Microanalysis*. Cambridge, MA: Ballinger.

Burstein, L., Aschbacher, P., Chen, Z., Lin, L. & Sen, Q. (1986). *Establishing the content validity of tests designed to serve multiple purposes: Bridging secondary-postsecondary mathematics*. Los Angeles: UCLA Center for the Study of Evaluation.

Burstein, L., Kim, K-S., & Chen, Z. (1988). *Preliminary analysis of the pilot data from the mathematics diagnostic testing program teacher topic coverage questionnaire.* Los Angeles: UCLA Center for the Study of Evaluation.

Burstein, L., Chen, Z., & Kim, K-S. (1989). *Analysis of Procedures for Assessing Content Coverage and Its Effects on Student Achievement.* Los Angeles: UCLA Center for the Study of Evaluation.

Burstein, L (1990). *Thoughts on Modern Achievemtn Modeling: Conceptual Considerations.* Presented at Instructionally Sensitive Psychometrics meeting at UCLA.

Cole, N.S. (1988). *A realist's appraisal of the prospects for unifying instruction and assessment.* In Assessment in the service of learning: Proceedings of the 1987 ETS Invitational Conference. Princeton, NJ: Educational Testing Service.

Gold, K. (1990). *Applications of Hierarchical Confirmatory Factor Models: Assessment of Structure and Integration of Knowledge Exhibited in Achievement Data.* Unpublished doctoral dissertation, University of California, Los Angeles.

Haertel, E. & Calfee, R. (1983). School Achievement: Thinking about What to Test, *Journal of Educational Measurement*, 20(2), 119-132.

Harnisch, D. L. (1983). Item Response Pattern: Applications for Educational Practice, *Journal Educational Measurement*, 20(2), 191-206.

Leinhardt, G. (1983). Overlap: Testing whether it's taught. In G.F. Madaus (Ed.), *The Courts, Validity, and Minimum Competency Testing*. Hingham, MA: Kluwer-Nijhoff Publishing.

Leinhardt, G., & Seewald, A.M. (1981). Overlap: What's tested, what's taught. *Journal of Educational Measurement*, 18, 85-96.

Linn, R. (1983). Testing and Instruction: Links and Distinctions, *Journal of Educational Measurement*, 20(2), 179-189.

McDonnell, L., Burstein, L., Ormseth, T., Catterall, J. & Moody, D. (1990). *Discovering what schools really teach: Designing improved coursework indicators*. Santa Monica, CA: The RAND Corporation.

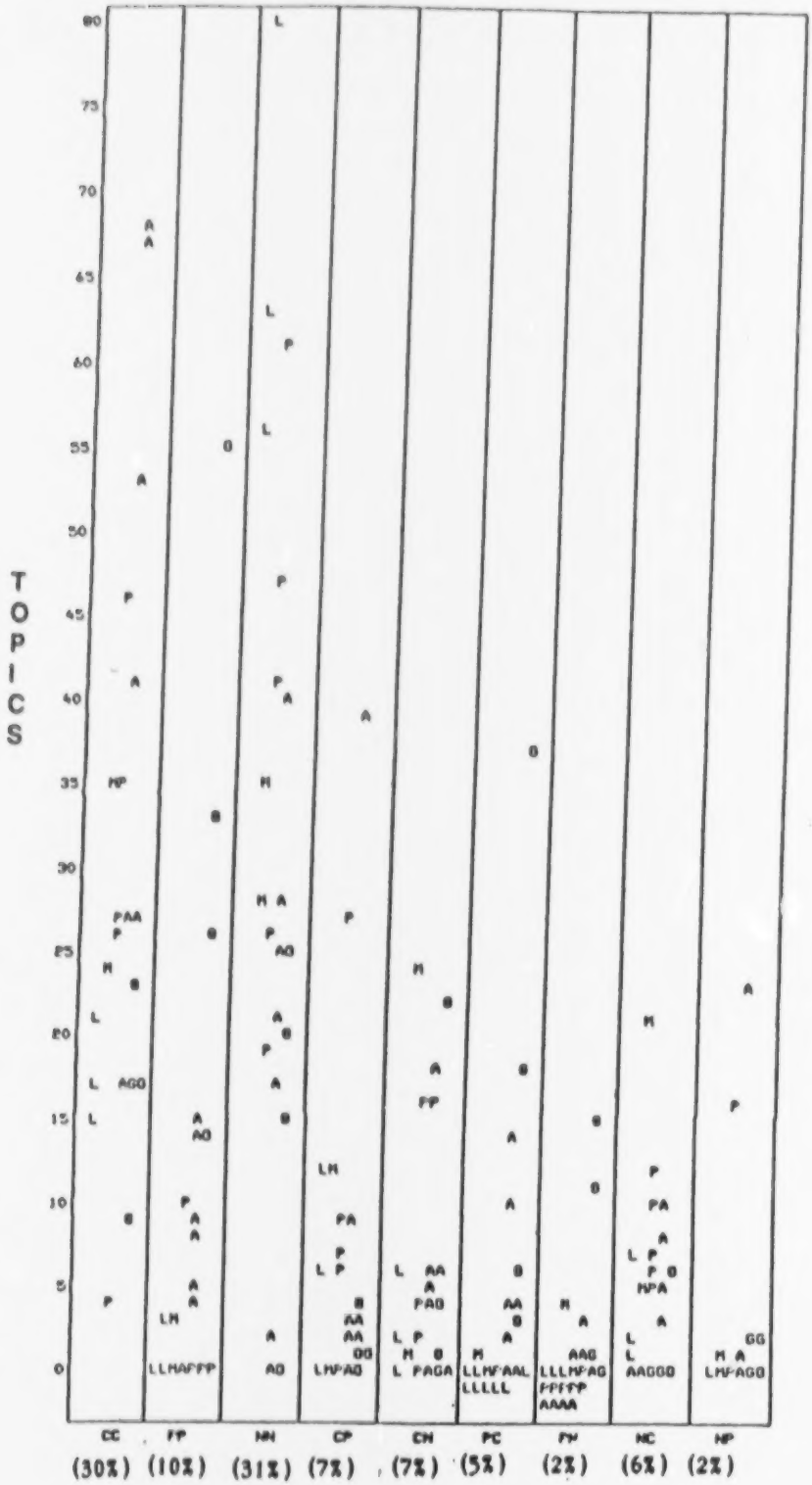
Muthén, B.O. (1989). *Instructionally Sensitive Psychometrics: Applications to the Second International Mathematics Study*. CRESST, UCLA.

Muthén, B.O., Kao, C-F, & Burstein, L. (1988). *Instructional sensitivity in mathematics achievement test items: Application of a new IRT-based detection technique*. Los Angeles, UCLA Center for the Study of Evaluation.

Schmidt, W.H. (1983). Content biases in achievement tests. *Journal of Educational Measurement*, 20(2), 165-178.

Yoon, B., Burstein, L.,Good, K,. Chen, Z., & Kim, K-S. (1990). *Validating teachers' reports of content coverage: An example of secondary school mathematics*. Presented at the National Coucil on Measurement in Education, Boston.

Figure 1. Plot of Topics with Content Coverage by Courses (Teachers' responses of content coverage for the same course for two consecutive years)



Content Coverage

Figure 2. Plot of Topics with Content Coverage by Courses (Teachers' responses of content coverage for the different courses for two consecutive years)

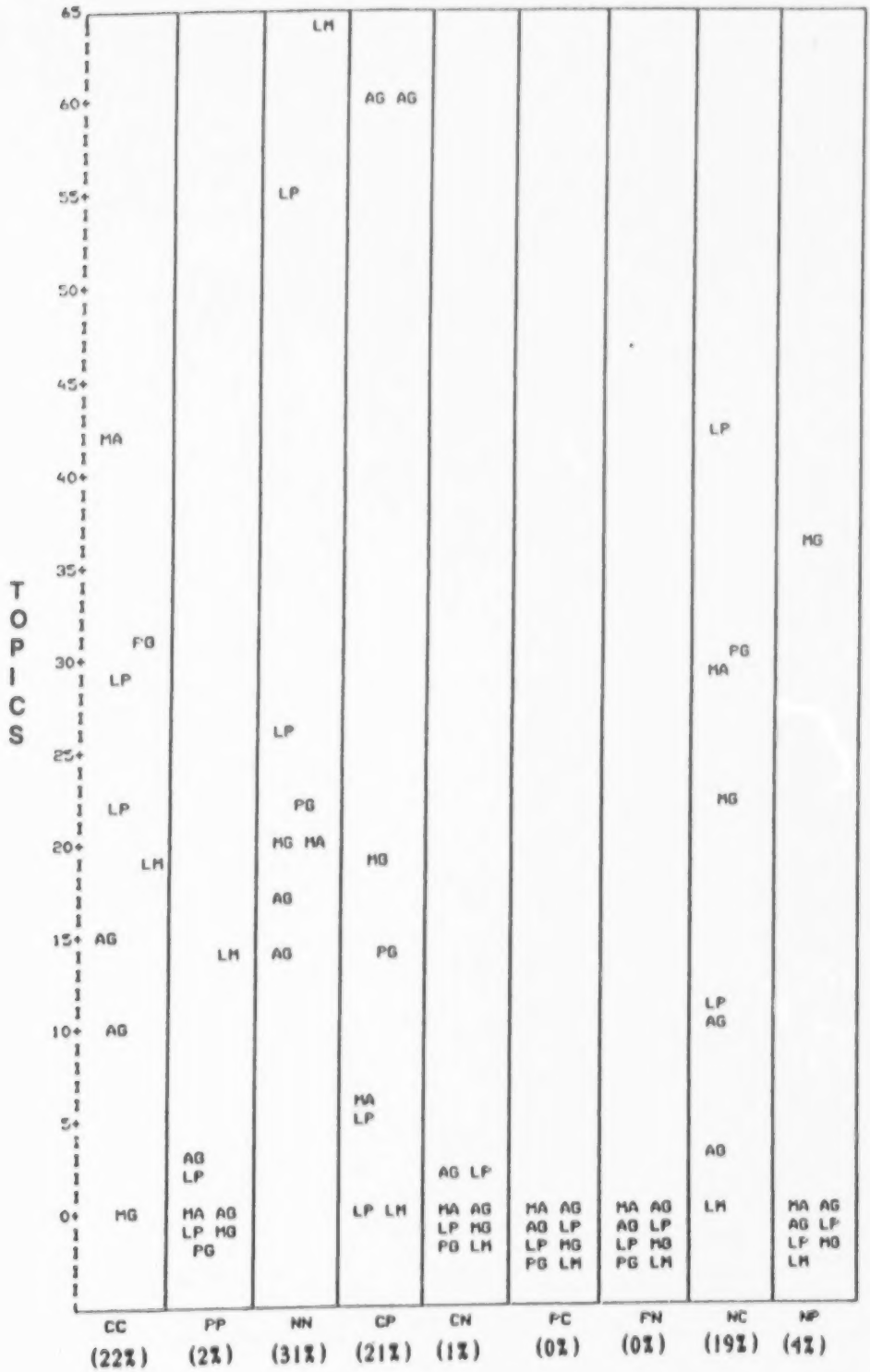
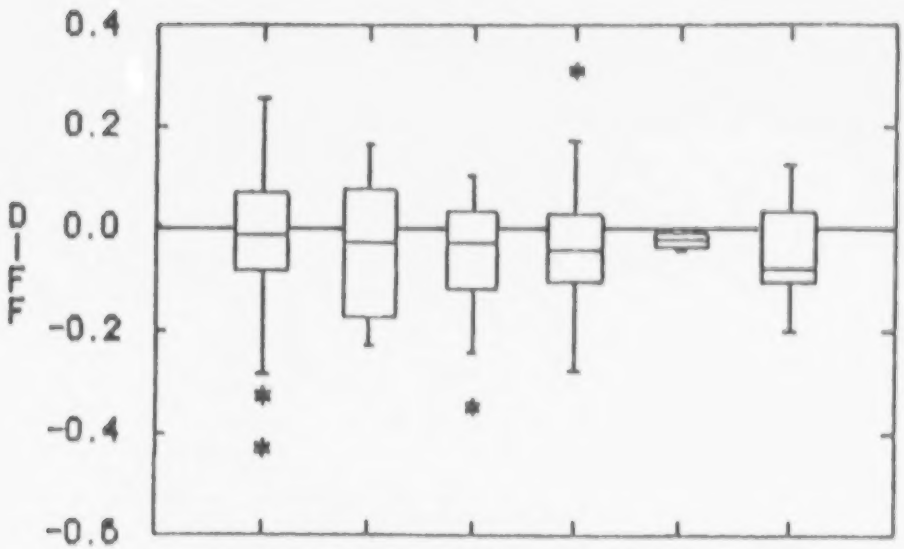


Figure 3. P-value difference distributions of students' performance on Algebra Readiness Test and Elementary Algebra Test



		CC (57%)	PP (3%)	NN (10%)	CP (21%)	CN (2%)	NC (7%)
Mean	'88	.43	.36	.29	.30	.30	.28
	'89	.44	.40	.35	.34	.32	.33

APPENDIX A

TABLE A-1 1988/1989 TEACHER CONTENT COVERAGE BY
SAME TEACHER SAME COURSES ACROSS YEARS
(Algebra Readiness Test)

	COURSE	LOWER THAN PRE ALGEBRA			MATH A		PRE ALGEBRA				
ITEMS	TEACHER	T16	T17	T18	T1	T3	T5	T8	T12	T14	T20
1 'BASIC OPERATIONS WITH SIGNED NO.'		CC	CC	NN	CP	CC	CP	CC	CC	CC	CP
2 'PRIME FACTORIZATION'		CC	CC	NN	CC	CC	CC	CC	CC	CC	CP
3 'FINDING DISTANCES ON NUMBER LINE'		CC	CC	NN	CC	CC	CC	CC	CP	NC	CP
4 'USING DEFINITION OF DIVISIBILITY'		CC	CC	NN	CC	CC	CP	CC	CP	CC	CP
5 'ADD. & SUB. OF FRACTIONS'		CP	CP	CC	CP	CC	CP	CP	CP	CC	PP
6 'MUL. & DIV. OF FRACTIONS'		CP	CP	CC	CP	CC	CP	CP	CP	CC	PP
7 'ORDER & COMPARISON OF FRACTIONS'		CP	CP	CC	CP	CC	CC	CP	CP	CC	PP
8 'SIMPLIF. OF COMPLEX FRACTIONS'		CP	CP	CC	CP	CC	CC	CP	CP	CC	CP
9 'ADD. & SUB OF DECIMALS'		CP	CP	CC	CP	CC	CP	CP	CP	CC	PP
10 'MUL. & DIV. OF DECIMALS'		CP	CP	CC	CP	CC	CP	CP	CC	CC	PP
11 'ESTIMATION & APPROXIMATION'		CC	CC	CC	CP	NP	CC	CC	CC	CC	PP
12 'CONV. BET. FRACTIONS & DECIMALS '		CC	CP	CC	CP	CC	CC	CC	CC	CC	PP
13 'CONV. BET. FRACTIONS & PERCENT'		CC	CP	CC	CP	CC	CC	CC	CC	CC	PP
14 'COMPUT. WITH DECI & FRAC, ROUND'		CC	CC	CC	CP	CC	CC	CC	CC	CC	PP
15 'COMPUTATION OF PERCENT'		CC	CP	CC	CP	CC	CC	CC	CC	CC	PP
16 'CONCEPT OF PROPORTION'		CC	PP	CC	CC	PP	CC	CC	CC	CC	CC
17 'COMPUTATION OF PROPORTIONS'		CC	PP	CC	CC	PP	CC	CC	CC	CC	CP
18 'APPLIC. OF RATIO OR PROPORTIONS'		CC	PP	CC	CC	PP	CC	CC	CC	CC	CP
19 'APPLIC. LAWS OF EXPONENTS'		CC	CP	NN	CC	CC	CC	NN	CC	NC	CP
20 'POWERS OF 10 & SCIENTIFIC NOTAT.'		CC	CP	NN	CC	PC	CC	NN	CC	CC	CP
21 'EXPONENT. WITH INTEGRAL EXPONEN.'		CC	CP	NN	CC	NC	CC	NC	CN	NC	CP
22 'SQ. ROOT OF PERFECT SQUARES'		NC	NC	NN	CC	PN	CC	CC	CN	NC	CC
23 'SIMPLIFICATION OF SQ. ROOTS'		NN	NC	NN	CC	PN	CC	CC	CN	NN	NP
24 'ADD. & SUB. OF SQ. ROOTS'		NN	NC	NN	CC	PN	CC	CN	CN	NN	NP
25 'MUL. & DIV. OF SQ. ROOTS'		NN	NC	NN	CN	PN	CC	CN	CN	NN	NP
26 'CONV. BET. RADICALS & RAT. EXPO.'		NN	NN	NN	NN	NN	CP	NN	CN	NN	NN
27 'RATIONALIZ. OF NUMERA. & DENOMI.'		NN	NN	NN	NC	NN	CP	NN	NN	NN	NP
28 'ADD. AND SUB. OF RADICAL EXPRE. '		NN	NN	NN	NN	NN	CN	NN	NN	NN	NN
29 'NUM. CALCU. W/ EXPONENTS & RAD. '		NN	NN	NN	NC	CN	CC	NN	NN	NN	NN
30 'ALGE. CALCU. W/ EXPONENTS & RAD.'		NN	NN	NN	NN	CN	CP	NN	NN	NN	NN
31 'FACTORING & SIMPLI. ALGE. EXPRE.'		NN	NN	NN	NC	CN	CC	NN	NN	NN	NN
32 'ESTIM. & APPROXI. WITH RADICALS.'		NN	NN	NN	NC	NN	CC	NN	NC	NN	NN
33 'ALGE OPERATION OF LITERAL SYMBOL'		CN	NN	NN	CC	CN	CC	CC	NN	CC	CP
34 'SIMPLIF. OF POLYNO. BY GROUPING.'		NN	NN	NN	NC	CN	CN	CC	NN	NC	CP
35 'ADD. & SUB. OF POLYNOMIALS'		NN	NN	NN	CC	CN	CN	CC	NN	NN	CP
36 'EVALUATION OF A POLYNOMIAL(1/2) '		NN	NN	NN	CC	CN	CN	CC	NN	NC	CP
37 'MUL. OF MONOMIAL WITH A POLYNO. '		NN	NN	NN	CC	CN	CN	NN	NN	NN	CP
38 'MUL. OF TWO BINOMIALS'		NN	NN	NN	NC	CN	CN	NN	NN	NN	NP
39 'DIVISION OF POLYNOMIALS'		NN	NN	NN	CC	CN	CN	NN	NN	NN	NP
40 'SQUARING A BINOMIAL'		NN	NN	NN	NC	CN	CN	NN	NN	NN	NP
41 'FACTOR. POLYNOMIALS'		NN	NN	NN	NC	CN	CN	NN	NN	NN	CP
42 'FACTOR. TRINOMIAL OVER INTEGERS '		NN	NN	NN	NN	CN	CN	NN	NN	NN	NP
43 'FACTOR. PERFECT SQ. TRINOMIALS '		NN	NN	NN	NC	CN	CN	NN	NN	NN	NP
44 'SIMPLIF. OF COMPLEX NUMBERS'		NN	NN	NN	NN	NN	CN	NN	NC	NN	NN
45 'ONE UNKNOWN WITH NUM. COEFFI.'		NN	NN	NN	CC	CC	CC	CC	CC	NN	CP
46 'ONE UNKNOWN WITH LIT. COEFFI.'		NN	NN	NN	CC	CC	CC	CC	CC	NN	NN
47 'SIMPLE LIN. EQUA. IN ONE UNKNOWN'		NN	NN	NN	CC	CC	CC	CC	CN	NN	CP
48 'TWO UNKNOWN BY ELIMINATION'		NN	NN	NN	NN	NN	CC	CN	NN	NN	NP
49 'TWO UNKNOWN BY SUBSTITUTION'		NN	NN	NN	NN	NN	CC	CN	NN	NN	NP
50 'APPLICATION OF EQUATIONS'		NN	NN	NN	NN	CC	CC	CC	CC	NN	CP

TABLE A-1 1988/1989 TEACHER CONTENT COVERAGE BY
SAME TEACHER SAME COURSES ACROSS YEARS
(Algebra Readiness Test)

	COURSE	LOWER THAN PRE ALGEBRA			MATH A		PRE ALGEBRA				
ITEMS	TEACHER	T16	T17	T18	T1	T3	T5	T8	T12	T14	T20
51 'GENERATING EQUATIONS FROM DESCR.'		NN	NN	NN	CC	CC	CC	CC	CN	NN	CP
52 'SOLV. EQUA. FROM FACTORED FORM'		NN	NN	NN	NN	NN	NC	NN	NN	NN	NP
53 'SOLVING QUAD.EQUAT.BY FACTORING'		NN	NN	NN	NN	NN	NC	NN	NN	NN	NP
54 'SOLV. QUAD. EQUA. BY QUADRATIC'		NN	NN	NN	NN	NN	NC	NN	NN	NN	NP
55 'GRAPHS OF QUADRATIC RELATIONS'		NN	NN	NN	NC	NN	NC	NN	NN	NN	NN
56 'ONE UNKNOWN WITH NUM. COEFFI.'		NN	NN	NN	CC	CN	CC	CC	CN	NN	CP
57 'SOLUT. OF QUADRATIC INEQUALITIES'		NN	NN	NN	NC	NN	CC	NN	CN	NN	NN
58 'GRAPHING LIN. INEQ. IN ONE UNKNO'		NN	NN	NN	CC	CN	CC	CC	CC	NN	NN
59 'SIMPLIF. OF A RATIONAL EXPRE.'		NN	NN	NN	NC	CC	CC	CC	NC	NN	CP
60 'EVALUATION OF A RATIONAL EXPRE.'		NN	NN	NN	CC	CC	CC	CC	NC	NN	CP
61 'ADD. & SUB. OF RATIONAL EXPRE.'		NN	NN	NN	CC	CN	CC	CC	NC	NN	CP
62 'MUL. & DIV. OF RATIONAL EXPRE.'		NN	NN	NN	CC	NN	CC	CC	NC	NN	CP
63 'PROBABILITY'		CC	CN	NN	CC	CC	NN	NN	CC	NN	NN
64 'DESCRIPTIVE STATISTICS'		CC	CN	NN	NC	CC	NN	NN	CC	NN	NN
65 'GRAPH READING'		CC	CC	NN	CC	CN	CC	CC	CC	NC	CP
66 'LOCATI. OF POINTS IN CORD. PLANE'		CC	CC	NN	CC	CN	CC	CC	CC	NC	CP
67 'DISTANCE BET. TWO POINTS IN COR.'		CC	CC	NN	NC	NN	CC	CC	CC	NC	NC
68 'PERIMETER & AREA OF TRIANGLES,SQ'		CC	CC	CC	CC	CN	CC	CC	CC	CC	CC
69 'CIRCUMFERENCE & AREA OF CIRCLE'		CN	CC	NC	CC	CN	CC	CC	CC	CC	CC
70 'VOL. OF CUBES, CYLINDERS,RECTAN.'		NN	CC	NC	CC	NN	CC	NC	CC	NN	NC
71 'FINDING SUM OF INTERIOR ANGLES'		CN	CC	NN	NC	NC	NN	NC	CC	CC	NC
72 'ISOSCELES & EQUILATERAL TRIANGLE'		CN	CC	NN	NC	NC	NC	NC	CN	CC	NC
73 'APPLIC., CONGRUENT TRIANGLES'		CN	CC	NN	NC	NN	NC	NN	CN	CC	NC
74 'APPLIC., SIMPLE TRIANGLES'		CN	CC	NN	NC	NN	NC	NN	CN	CC	NC
75 'PYTHAGOREAN THEOREM & SPECI. TR.'		NN	NC	NN	NC	NC	CC	NN	CC	NC	NC
76 'PARALLELISM & PERPENDICULARITY'		NN	CC	NN	NN	NC	NN	NN	CN	CC	NC
77 'PROOFS(FORMAL DEDUCTIVE DEMONST.'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NC
78 'TRANSFORMATIONS(TRANSLATION.'		NN	NN	NN	NN	NN	NN	NC	NN	NN	NN
79 'VECTORS'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
80 'SIMPLIF. & EVALU. OF EXPRESS.'		NN	NC	NN	CC	NN	CC	CC	CN	NN	NP
81 'SOLUTION OF EQUATIONS'		NN	NC	NN	NC	NN	CC	NN	CN	NN	NP
82 'FUNCT. CONCEPT & USE OF NOTATION'		NN	NN	NN	CC	CN	CN	NN	NN	NN	CN
83 'FUNCT. EVALUATION USING SUBSTIT.'		NN	NN	NN	CC	CN	CN	NN	NN	NN	CN
84 'COMPOSITION OF FUNCTION'		NN	NN	NN	NN	NN	CN	NN	NN	NN	NN
85 'GRAPHING OF FUNCTION'		NN	NN	NN	NN	NN	CN	NN	NN	NN	NN
86 'NUMERICAL FUNCTIONALEVALUATION'		NN	NN	NN	NN	CN	NN	NN	NN	NN	NN
87 'SUBSTITUTING LITERAL EXPRESS.'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
88 'DEFINITION, LAWS & RULES'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
89 'INVERSE RELATION BET. LOG. & EXP'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
90 'SOLUTION OF LOG. AND EXP. FUNCT.'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
91 'GRAPHING OF LOG. AND EXP. FUNCT.'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
92 'FIND. ALGEBRAIC EXPRESS'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NC
93 'DESCRIB. VARIATIONS OF FUNCTION'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NC
94 'FIND. SIDE LENGTHS IN SPEC.TRIA.'		NN	NN	NN	NC	NN	NN	NN	NN	NN	NC
95 'GRAPHING TRIGONOMETRIC FUNCTIONS'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
96 'REDUCING TRIGONOMETRIC EXPRE.'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN
97. 'PROOF OF TRIGONOMETRIC IDENTITIE'		NN	NN	NN	NN	NN	NN	NN	NN	NN	NN

TABLE A-2 1989/1989 TEACHER CONTENT COVERAGE BY
SAME TEACHER SAME COURSES ACROSS YEARS
(Elementary Algebra Test)

	ALGEBRA I							GEOMETRY			
ITEMS	T4	T10	T11	T13	T14	T15	T19	T4	T7	T9	T15
1 'BASIC OPERATIONS WITH SIGNED NO.'	CC	CC	PC	PC	CP	CP	CC	PP	PP	PP	PC
2 'PRIME FACTORIZATION'	CC	CC	PC	CP	CP	CP	CC	PP	PC	PP	PC
3 'FINDING DISTANCES ON NUMBER LINE'	CC	CC	PC	PP	CP	CP	CC	CC	PC	PC	PC
4 'USING DEFINITION OF DIVISIBILITY'	CC	PP	PC	PP	PP	CP	CC	CP	PP	PP	PC
5 'ADD. & SUB. OF FRACTIONS'	CC	CC	PC	PC	PP	PP	PP	PP	PC	PP	PP
6 'MUL. & DIV. OF FRACTIONS'	CC	CC	PC	PC	PP	PP	PP	PP	PC	PP	PP
7 'ORDER & COMPARISON OF FRACTIONS'	CC	CC	PC	PC	PP	PP	PP	PP	PP	PP	PP
8 'SIMPLIF. OF COMPLEX FRACTIONS'	CC	CC	PC	CC	PP	PP	CC	PP	PC	NC	PP
9 'ADD. & SUB OF DECIMALS'	CP	CC	PC	PC	PP	PP	PP	PP	PC	PP	PP
10 'MUL. & DIV. OF DECIMALS'	CP	CC	PC	PC	PP	PP	PP	PP	PC	PP	PP
11 'ESTIMATION & APPROXIMATION'	CP	CC	PN	PC	PP	PP	PP	PP	PC	CP	PP
12 'CONV. BET. FRACTIONS & DECIMALS '	CC	CC	PP	PC	PP	PP	PP	PP	PC	PP	PP
13 'CONV. BET. FRACTIONS & PERCENT'	CC	CP	PP	PC	PP	PP	PP	PP	PC	PP	PP
14 'COMPUT. WITH DECI & FRAC, ROUND'	CC	CC	PP	PC	PP	PP	PC	PP	PC	PP	PP
15 'COMPUTATION OF PERCENT'	CC	CC	PC	PP	CP	PP	CN	PP	PC	PP	PP
16 'CONCEPT OF PROPORTION'	CC	CC	PC	PP	CP	PP	CC	CP	PC	CC	PP
17 'COMPUTATION OF PROPORTIONS'	CC	CP	PC	PP	CP	PP	CC	CP	PC	CC	PP
18 'APPLIC. OF RATIO OR PROPORTIONS'	CC	CC	PC	CP	CP	PP	CC	CP	PC	CC	PP
19 'APPLIC. LAWS OF EXPONENTS'	CC	CC	NC	CC	CC	CC	CC	PP	PC	PP	PC
20 'POWERS OF 10 & SCIENTIFIC NOTAT.'	CC	CC	NP	CC	CC	CC	CC	CC	PP	PN	PC
21 'EXPONENT. WITH INTEGRAL EXPONEN.'	CC	CC	NC	CC	CC	CC	CC	CC	PP	PP	PC
22 'SQ. ROOT OF PERFECT SQUARES'	CC	CC	PP	CC	NN	PC	CC	CC	PC	CC	PC
23 'SIMPLIFICATION OF SQ. ROOTS'	CC	CC	NC	CC	NN	PC	CC	CC	PC	CC	PC
24 'ADD. & SUB. OF SQ. ROOTS'	CC	CC	NC	CC	NN	PC	CC	CC	PP	CC	PC
25 'MUL. & DIV. OF SQ. ROOTS'	CC	CC	NC	CC	NN	PC	CC	CC	PP	CC	PC
26 'CONV. BET. RADICALS & RAT. EXPO.'	CC	CC	CN	CC	NN	CC	CC	PP	CC	CC	PN
27 'RATIONALIZ. OF NUMERA. & DENOMI.'	CC	CC	CN	CC	NN	CC	CC	PP	CC	CC	PN
28 'ADD. AND SUB. OF RADICAL EXPRE. '	CC	CC	CN	CC	NN	CC	CC	PP	CP	NN	PN
29 'NUM. CALCU. W/ EXPONENTS & RAD. '	CC	CC	CN	CC	NN	CC	CC	PP	CC	NP	PN
30 'ALGE. CALCU. W/ EXPONENTS & RAD.'	CC	CC	CN	CC	NN	CC	CN	PP	CC	NN	PN
31 'FACTORING & SIMPLI. ALGE. EXPRE.'	CC	CC	CN	CN	NN	CC	CN	PP	CC	NC	PN
32 'ESTIM. & APPROXI. WITH RADICALS.'	CC	CC	CN	CN	NN	CC	CC	PP	CN	NC	PN
33 'ALGE OPERATION OF LITERAL SYMBOL'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
34 'SIMPLIF. OF POLYNO. BY GROUPING.'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
35 'ADD. & SUB. OF POLYNOMIALS'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
36 'EVALUATION OF A POLYNOMIAL(1/2) '	CC	CC	CC	CC	CC	CP	CC	PP	PP	PC	PC
37 'MUL. OF MONOMIAL WITH A POLYNO. '	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
38 'MUL. OF TWO BINOMIALS'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
39 'DIVISION OF POLYNOMIALS'	CC	CC	CC	CC	CC	CP	CC	PP	PP	NN	PN
40 'SQUARING A BINOMIAL'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
41 'FACTOR. POLYNOMIALS'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
42 'FACTOR. TRINOMIAL OVER INTEGERS '	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
43 'FACTOR. PERFECT SQ. TRINOMIALS '	CC	CC	CC	CC	CC	CP	CC	PP	PP	PP	PC
44 'SIMPLIF. OF COMPLEX NUMBERS'	CC	CC	CC	CC	CC	CP	CC	PP	PP	NN	PC
45 'ONE UNKNOWN WITH NUM. COEFFI.'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PC	PC
46 'ONE UNKNOWN WITH LIT. COEFFI.'	CC	CC	CC	CC	CC	CP	CC	PP	PP	NN	PC
47 'SIMPLE LIN. EQUA. IN ONE UNKNOWN'	CC	CC	CC	CC	CC	CP	CC	PP	PP	PC	PC
48 'TWO UNKNOWN BY ELIMINATION'	CC	CC	CC	CC	CN	CP	CC	PP	PP	PP	PC
49 'TWO UNKNOWN BY SUBSTITUTION'	CC	CC	CC	CC	CN	CP	CC	PP	PP	PP	PC
50 'APPLICATION OF EQUATIONS'	CC	CC	CC	CC	CC	CP	CC	PP	PP	CC	PC

TABLE A-2 1989/1989 TEACHER CONTENT COVERAGE BY SAME TEACHER SAME COURSES ACROSS YEARS (Elementary Algebra Test)

ITEMS	ALGEBRA I							GEOMETRY			
	T4	T10	T11	T13	T14	T15	T19	T4	T7	T9	T15
51 'GENERATING EQUATIONS FROM DESCR.'	CC	NC	CC	CC	CC	CP	CC	PP	PP	CC	PC
52 'SOLV. EQUA. FROM FACTORED FORM'	CC	CC	NC	CC	NN	CP	CC	PP	PN	PC	PN
53 'SOLVING QUAD.EQUAT.BY FACTORING'	CC	CC	NC	CC	NN	CP	CC	PP	PN	CC	PN
54 'SOLV. QUAD. EQUA. BY QUADRATIC'	CC	CC	NC	CN	NN	CP	CC	PP	PN	NN	PN
55 'GRAPHS OF QUADRATIC RELATIONS'	CC	CC	NN	NN	NN	CP	CC	PP	PN	NN	PN
56 'ONE UNKNOWN WITH NUM. COEFFI.'	CC	CC	CC	CC	CC	CP	CC	PP	PN	PP	PN
57 'SOLUT. OF QUADRATIC INEQUALITIES'	CC	CC	CC	CN	NN	CP	CC	PP	PN	NN	PN
58 'GRAPHING LIN. INEQ. IN ONE UNKNO'	CC	CC	CN	CN	CN	CP	CC	PP	PN	PP	PN
59 'SIMPLIF. OF A RATIONAL EXPRE.'	CC	CC	CC	CC	CC	CP	CC	PP	PN	PP	PC
60 'EVALUATION OF A RATIONAL EXPRE.'	CC	CC	CC	CC	CC	CC	CC	PP	PN	PP	PC
61 'ADD. & SUB. OF RATIONAL EXPRE.'	CC	CC	CC	CC	CC	CP	CC	PP	PN	PP	PC
62 'MUL. & DIV. OF RATIONAL EXPRE.'	CC	CC	CC	CC	CC	CP	CC	PP	PN	PP	PC
63 'PROBABILITY'	NC	NN	CN	NN	NN	CC	NN	NN	NN	NN	CC
64 'DESCRIPTIVE STATISTICS'	NC	NN	NN	NN	NN	CC	NN	NN	NN	NN	CC
65 'GRAPH READING'	CC	PC	CN	NN	CN	CP	CN	PC	CN	PP	CC
66 'LOCATI. OF POINTS IN CORD. PLANE'	CC	PC	CN	NN	CN	CP	CC	PC	CC	PC	CC
67 'DISTANCE BET. TWO POINTS IN COR.'	CC	PC	CN	NN	CC	CC	CC	PC	CC	CC	CN
68 'PERIMETER & AREA OF TRIANGLES,SQ'	CC	PC	CP	NC	CP	CP	PC	CC	CC	CC	CC
69 'CIRCUMFERENCE & AREA OF CIRCLE'	NN	PP	CP	NC	PP	CP	NC	CC	CC	CC	CC
70 'VOL. OF CUBES, CYLINDERS,RECTAN.'	NN	PP	CP	NN	NN	CP	NN	CC	CC	CC	CC
71 'FINDING SUM OF INTERIOR ANGLES'	NC	PP	NN	NC	CP	NP	NN	CC	CC	CC	CN
72 'ISOSCELES & EQUILATERAL TRIANGLE'	NC	PP	NN	NC	PP	NP	NN	CC	CC	CC	CN
73 'APPLIC., CONGRUENT TRIANGLES'	NC	PP	NN	NN	PP	NP	NN	CC	CC	CC	CN
74 'APPLIC., SIMPLE TRIANGLES'	NN	PP	NN	NN	PP	NP	NN	CC	CC	CC	CN
75 'PYTHAGOREAN THEOREM & SPECI. TR.'	NC	PP	CN	NC	NN	NP	NN	CC	CC	CC	CN
76 'PARALLELISM & PERPENDICULARITY'	NC	PP	CN	NN	PN	NP	NC	CC	CC	CC	CN
77 'PROOFS(FORMAL DEDUCTIVE DEMONST.'	NC	PN	NN	NN	NN	NP	NN	CC	CC	CC	CN
78 'TRANSFORMATIONS(TRANSLATION.'	NN	PN	NN	NN	NN	NP	NN	NN	CN	NC	CN
79 'VECTORS'	NN	PN	NN	NN	NN	NP	NN	NN	CN	NN	CN
80 'SIMPLIF. & EVALU. OF EXPRESS.'	CC	NC	CC	CC	NN	NP	NN	PP	NN	PP	CC
81 'SOLUTION OF EQUATIONS'	CC	NC	CC	CC	CC	CP	CC	PP	NN	NN	CC
82 'FUNCT. CONCEPT & USE OF NOTATION'	CC	CC	CN	CN	NN	CC	NC	PP	NN	NP	PC
83 'FUNCT. EVALUATION USING SUBSTIT.'	CC	CC	CN	NN	NN	CC	NC	PP	NN	NN	PC
84 'COMPOSITION OF FUNCTION'	NC	CC	CN	NN	NN	CC	NC	NP	NN	NN	PC
85 'GRAPHING OF FUNCTION'	NC	CC	CN	NN	NN	NP	NN	NP	NN	NC	PC
86 'NUMERICAL FUNCTIONALEVALUATION'	NN	CC	NN	NN	NN	NP	NN	NN	NN	NN	CN
87 'SUBSTITUTING LITERAL EXPRESS.'	NN	CC	NN	NN	NN	NP	NN	NN	NN	NN	CN
88 'DEFINITION, LAWS & RULES'	NN	CC	NN	NN	NN	NP	NN	NN	NN	NN	CN
89 'INVERSE RELATION BET. LOG. & EXP'	NN	CC	NN	NN	NN	NP	NN	NN	NN	NN	CN
90 'SOLUTION OF LOG. AND EXP. FUNCT.'	NN	CC	NN	NN	NN	NP	NN	NN	NN	NN	CN
91 'GRAPHING OF LOG. AND EXP. FUNCT.'	NN	CC	NN	NN	NN	NP	NN	NN	NN	NN	CN
92 'FIND. ALGEBRAIC EXPRESS'	NN	CN	NN	NN	NN	NP	NN	NN	NN	NN	CN
93 'DESCRIB. VARIATIONS OF FUNCTION'	NN	CN	NN	NN	NN	NP	NN	NN	NN	NN	CN
94 'FIND. SIDE LENGTHS IN SPEC.TRIA.'	NN	CN	NN	NN	NN	NP	NN	CN	NN	NC	CN
95 'GRAPHING TRIGONOMETRIC FUNCTIONS'	NN	CN	NN	NN	NN	NP	NN	NN	NN	NN	CN
96 'REDUCING TRIGONOMETRIC EXPRE.'	NN	CN	NN	NN	NN	NP	NN	NN	NN	NN	CN
97. 'PROOF OF TRIGONOMETRIC IDENTITIE'	NN	CN	NN	NN	NN	NP	NN	NN	NN	NN	CN

APPENDIX B

TABLE B-1

TEACHER CONTENT COVERAGE BY SAME TEACHER DIFFERENT COURSES 1988

ITEMS	MATH A /ALGEBRA I T1	ALGEBRA /GEOM T4	LOWER THAN PRE-ALG /PRE-ALG T5	MATH A /GEOM T7	PRE-ALG /GEOM T8
1 'BASIC OPERATIONS WITH SIGNED NO.'	CC	CP	CC	CP	CP
2 'PRIME FACTORIZATION'	CC	CP	CC	CP	CP
3 'FINDING DISTANCES ON NUMBER LINE'	CC	CC	CC	CP	CP
4 'USING DEFINITION OF DIVISIBILITY'	CC	CC	CC	CP	CP
5 'ADD. & SUB. OF FRACTIONS'	CC	CP	CC	CP	CP
6 'MUL. & DIV. OF FRACTIONS'	CC	CP	CC	CP	CP
7 'ORDER & COMPARISON OF FRACTIONS'	CC	CP	CC	CP	CP
8 'SIMPLIF. OF COMPLEX FRACTIONS'	CC	CP	CC	CP	CP
9 'ADD. & SUB OF DECIMALS'	CP	CP	CC	CP	CP
10 'MUL. & DIV. OF DECIMALS'	CP	CP	CC	CP	CP
11 'ESTIMATION & APPROXIMATION'	CP	CP	CC	CP	CP
12 'CONV. BET. FRACTIONS & DECIMALS '	CP	CP	CC	CP	CP
13 'CONV. BET. FRACTIONS & PERCENT'	CP	CP	CC	CP	CP
14 'COMPUT. WITH DECI & FRAC, ROUND'	CP	CP	CC	CP	CP
15 'COMPUTATION OF PERCENT'	CC	CP	CC	CP	CC
16 'CONCEPT OF PROPORTION'	CC	CC	CC	CP	CC
17 'COMPUTATION OF PROPORTIONS'	CC	CC	CC	CP	CC
18 'APPLIC. OF RATIO OR PROPORTIONS'	CC	CC	CC	CP	CC
19 'APPLIC. LAWS OF EXPONENTS'	CC	CP	NC	CP	NC
20 'POWERS OF 10 & SCIENTIFIC NOTAT.'	CC	CP	NC	NP	NN
21 'EXPONENT. WITH INTEGRAL EXPONEN.'	CC	CP	NC	NP	NN
22 'SQ. ROOT OF PERFECT SQUARES'	CC	CC	CC	NP	CC
23 'SIMPLIFICATION OF SQ. ROOTS'	CC	CC	CC	NP	CC
24 'ADD. & SUB. OF SQ. ROOTS'	CC	CC	NC	NP	CC
25 'MUL. & DIV. OF SQ. ROOTS'	CC	CC	NC	NP	CC
26 'CONV. BET. RADICALS & RAT. EXPO.'	NC	CP	NC	NC	NN
27 'RATIONALIZ. OF NUMERA. & DENOMI.'	NC	CP	NC	NC	NC
28 'ADD. AND SUB. OF RADICAL EXPRE. '	NC	CP	NC	NC	NC
29 'NUM. CALCU. W/ EXPONENTS & RAD. '	NC	CP	NC	NC	NC
30 'ALGE. CALCU. W/ EXPONENTS & RAD.'	NC	CP	NC	NC	NN
31 'FACTORING & SIMPLI. ALGE. EXPRE.'	NC	CP	NC	NC	NN
32 'ESTIM. & APPROXI. WITH RADICALS.'	NC	CP	NC	NC	NC
33 'ALGE OPERATION OF LITERAL SYMBOL'	CC	CP	NC	NP	CC
34 'SIMPLIF. OF POLYNO. BY GROUPING.'	NC	CP	NC	NP	CC
35 'ADD. & SUB. OF POLYNOMIALS'	CC	CP	NC	NP	CC
36 'EVALUATION OF A POLYNOMIAL(1/2) '	CC	CP	NC	NP	CC
37 'MUL. OF MONOMIAL WITH A POLYNO. '	CC	CP	NC	NP	NC
38 'MUL. OF TWO BINOMIALS'	NC	CP	NC	NP	NC
39 'DIVISION OF POLYNOMIALS'	CC	CP	NC	NP	NC
40 'SQUARING A BINOMIAL'	NC	CP	NC	NP	NC
41 'FACTOR. POLYNOMIALS'	NC	CP	NC	NP	NC
42 'FACTOR. TRINOMIAL OVER INTEGERS '	NC	CP	NC	NP	NC
43 'FACTOR. PERFECT SQ. TRINOMIALS '	NC	CP	NC	NP	NC
44 'SIMPLIF. OF COMPLEX NUMBERS'	NC	CP	NC	NP	NC
45 'ONE UNKNOWN WITH NUM. COEFFI.'	CC	CP	CC	NP	CC
46 'ONE UNKNOWN WITH LIT. COEFFI.'	CC	CP	CC	NP	CC
47 'SIMPLE LIN. EQUA. IN ONE UNKNOWN'	CC	CP	CC	NP	CC
48 'TWO UNKNOWN BY ELIMINATION'	NC	CP	NC	NP	CC
49 'TWO UNKNOWN BY SUBSTITUTION'	NC	CP	NC	NP	CC
50 'APPLICATION OF EQUATIONS'	NC	CP	NC	NP	CC
51 'GENERATING EQUATIONS FROM DESCR.'	CC	CP	NC	NP	CC

TABLE B-1

TEACHER CONTENT COVERAGE BY SAME TEACHER DIFFERENT COURSES 1988

ITEMS	MATH A /ALGEBRA I T1	ALGEBRA /GEOM T4	LOWER THAN PRE-ALG /PRE-ALG T5	MATH A /GEOM T7	PRE-ALG /GEOM T8
52 'SOLV. EQUA. FROM FACTORED FORM'	NC	CP	NN	NP	NC
53 'SOLVING QUAD.EQUAT.BY FACTORING '	NC	CP	NN	NP	NC
54 'SOLV. QUAD. EQUA. BY QUADRATIC '	NC	CP	NN	NP	NC
55 'GRAPHS OF QUADRATIC RELATIONS'	NC	CP	NN	NP	NC
56 'ONE UNKNOWN WITH NUM. COEFFI.'	CC	CP	NC	NP	CC
57 'SOLUT. OF QUADRATIC INEQUALITIES'	NC	CP	NC	NP	NC
58 'GRAPHING LIN. INEQ. IN ONE UNKNO'	CC	CP	NC	NP	CC
59 'SIMPLIF. OF A RATIONAL EXPRE.'	NC	CP	NC	NP	CC
60 'EVALUATION OF A RATIONAL EXPRE. '	CC	CP	NC	NP	CC
61 'ADD. & SUB. OF RATIONAL EXPRE.'	CC	CP	NC	NP	CC
62 'MUL. & DIV. OF RATIONAL EXPRE.'	CC	CP	NC	NP	CC
63 'PROBABILITY'	CC	NN	NN	NN	NN
64 'DESCRIPTIVE STATISTICS'	NC	NN	NN	NN	NN
65 'GRAPH READING'	CC	CP	CC	NC	CC
66 'LOCATI. OF POINTS IN CORD. PLANE'	CC	CP	CC	NC	CC
67 'DISTANCE BET. TWO POINTS IN COR.'	NC	CP	NC	NC	CC
68 'PERIMETER & AREA OF TRIANGLES,SQ'	CC	CC	CC	NC	CC
69 'CIRCUMFERENCE & AREA OF CIRCLE'	CC	NC	CC	NC	CC
70 'VOL. OF CUBES, CYLINDERS,RECTAN.'	CC	NC	CC	NC	NC
71 'FINDING SUM OF INTERIOR ANGLES'	NN	NC	NN	NC	NC
72 'ISOSCELES & EQUILATERAL TRIANGLE'	NN	NC	NN	NC	NC
73 'APPLIC. , CONGRUENT TRIANGLES'	NN	NC	NN	NC	NC
74 'APPLIC. , SIMPLE TRIANGLES'	NN	NC	NN	NC	NC
75 'PYTHAGOREAN THEOREM & SPECI. TR.'	NC	NC	CC	NC	NC
76 'PARALLELISM & PERPENDICULARITY'	NC	NC	NN	NC	NC
77 'PROOFS(FORMAL DEDUCTIVE DEMONST.'	NN	NC	NN	NC	NC
78 'TRANSFORMATIONS(TRANSLATION.'	NN	NN	NN	NC	NN
79 'VECTORS'	NN	NN	NN	NC	NN
80 'SIMPLIF. & EVALU. OF EXPRESS.'	CC	CP	NC	NN	CC
81 'SOLUTION OF EQUATIONS'	NC	CP	NC	NN	NC
82 'FUNCT. CONCEPT & USE OF NOTATION'	CC	CP	NC	NN	NN
83 'FUNCT. EVALUATION USING SUBSTIT.'	CC	CP	NC	NN	NN
84 'COMPOSITION OF FUNCTION'	NN	NN	NC	NN	NN
85 'GRAPHING OF FUNCTION'	NC	NN	NC	NN	NN
86 'NUMERICAL FUNCTIONALEVALUATION'	NN	NN	NN	NN	NN
87 'SUBSTITUTING LITERAL EXPRESS.'	NN	NN	NN	NN	NN
88 'DEFINITION, LAWS & RULES'	NN	NN	NN	NN	NN
89 'INVERSE RELATION BET. LOG. & EXP'	NN	NN	NN	NN	NN
90 'SOLUTION OF LOG. AND EXP. FUNCT.'	NN	NN	NN	NN	NN
91 'GRAPHING OF LOG. AND EXP. FUNCT.'	NN	NN	NN	NN	NN
92 'FIND. ALGEBRAIC EXPRESS'	NN	NN	NN	NN	NC
93 'DESCRIB. VARIATIONS OF FUNCTION '	NN	NN	NN	NN	NC
94 'FIND. SIDE LENGTHS IN SPEC.TRIA.'	NN	NC	NN	NN	NC
95 'GRAPHING TRIGONOMETRIC FUNCTIONS'	NN	NN	NN	NN	NN
96 'REDUCING TRIGONOMETRIC EXPRE.'	NN	NN	NN	NN	NN
97. 'PROOF OF TRIGONOMETRIC IDENTITIE'	NN	NN	NN	NN	NN

TABLE B-2

TEACHER CONTENT COVERAGE BY SAME TEACHER DIFFERENT COURSES 1989

ITEMS	LOWER THAN PRE-ALO / MATH A	ALO 1 / GEOMETRY	LOWER THAN PRE-ALO /PRE-ALO	LOWER THAN PRE-ALO /PREALO /ALO 1
	T3	T4	T12	T14
1 'BASIC OPERATIONS WITH SIGNED NO.'	CC	CP	NC	NCP
2 'PRIME FACTORIZATION'	CC	CP	CC	CCP
3 'FINDING DISTANCES ON NUMBER LINE'	CC	CC	PP	NCP
4 'USING DEFINITION OF DIVISIBILITY'	CC	CP	PP	CCP
5 'ADD. & SUB. OF FRACTIONS'	PP	CP	CP	CCP
6 'MUL. & DIV. OF FRACTIONS'	PP	CP	CP	CCP
7 'ORDER & COMPARISON OF FRACTIONS'	PP	CP	CP	CCP
8 'SIMPLIF. OF COMPLEX FRACTIONS'	PP	CP	CP	CCP
9 'ADD. & SUB OF DECIMALS'	PP	CP	CP	CCP
10 'MUL. & DIV. OF DECIMALS'	PP	CP	CC	CCP
11 'ESTIMATION & APPROXIMATION'	PP	CP	CC	CCP
12 'CONV. BET. FRACTIONS & DECIMALS '	PP	CP	CC	CCP
13 'CONV. BET. FRACTIONS & PERCENT'	PP	CP	CC	CCP
14 'COMPUT. WITH DECI & FRAC, ROUND'	PP	CP	CC	CCP
15 'COMPUTATION OF PERCENT'	PP	CP	CC	CCP
16 'CONCEPT OF PROPORTION'	PP	CP	CC	CCP
17 'COMPUTATION OF PROPORTIONS'	PP	CP	CC	CCP
18 'APPLIC. OF RATIO OR PROPORTIONS'	PP	CP	CC	CCP
19 'APPLIC. LAWS OF EXPONENTS'	CC	CP	CC	NCC
20 'POWERS OF 10 & SCIENTIFIC NOTAT.'	CC	CP	CC	NCC
21 'EXPONENT. WITH INTEGRAL EXPONEN.'	CC	CP	NN	NCC
22 'SQ. ROOT OF PERFECT SQUARES'	NN	CC	NN	NCN
23 'SIMPLIFICATION OF SQ. ROOTS'	NN	CC	NN	NNN
24 'ADD. & SUB. OF SQ. ROOTS'	NN	CC	NN	NNN
25 'MUL. & DIV. OF SQ. ROOTS'	NN	CC	NN	NNN
26 'CONV. BET. RADICALS & RAT. EXPO.'	NN	CP	NN	NNN
27 'RATIONALIZ. OF NUMERA. & DENOMI.'	NN	CP	NN	NNN
28 'ADD. AND SUB. OF RADICAL EXPRE. '	NN	CP	NN	NNN
29 'NUM. CALCU. W/ EXPONENTS & RAD. '	NN	CP	NN	NNN
30 'ALGE. CALCU. W/ EXPONENTS & RAD.'	NN	CP	NN	NNN
31 'FACTORING & SIMPLI. ALGE. EXPRE.'	NN	CP	NN	NNN
32 'ESTIM. & APPROXI. WITH RADICALS.'	NN	CP	NC	NNN
33 'ALGE OPERATION OF LITERAL SYMBOL'	NN	CP	NN	NCC
34 'SIMPLIF. OF POLYNO. BY GROUPING.'	NN	CP	NN	NCC
35 'ADD. & SUB. OF POLYNOMIALS'	NN	CP	NN	NNC
36 'EVALUATION OF A POLYNOMIAL(1/2) '	NN	CP	NN	NCC
37 'MUL. OF MONOMIAL WITH A POLYNO. '	NN	CP	NN	NNC
38 'MUL. OF TWO BINOMIALS'	NN	CP	NN	NNC
39 'DIVISION OF POLYNOMIALS'	NN	CP	NN	NNC
40 'SQUARING A BINOMIAL'	NN	CP	NN	NNC
41 'FACTOR. POLYNOMIALS'	NN	CP	NN	NNC
42 'FACTOR. TRINOMIAL OVER INTEGERS '	NN	CP	NN	NNC
43 'FACTOR. PERFECT SQ. TRINOMIALS '	NN	CP	NN	NNC
44 'SIMPLIF. OF COMPLEX NUMBERS'	NN	CP	NC	NNN
45 'ONE UNKNOWN WITH NUM. COEFFI.'	CC	CP	CC	NNC
46 'ONE UNKNOWN WITH LIT. COEFFI.'	NN	CP	CC	NNC
47 'SIMPLE LIN. EQUA. IN ONE UNKNOWN'	CC	CP	CN	NNC
48 'TWO UNKNOWN BY ELIMINATION'	NN	CP	NN	NNN
49 'TWO UNKNOWN BY SUBSTITUTION'	NN	CP	NN	NNN

TABLE B - 2

TEACHER CONTENT COVERAGE BY SAME TEACHER DIFFERENT COURSES 1989

ITEMS	LOWER THAN PRE-ALG/ MATH A	ALG I/ GEOMETRY	LOWER THAN PRE-ALG /PRE-ALG	LOWER THAN PRE-ALG /PREALG /ALG I
	T3	T4	T12	T14
50 'APPLICATION OF EQUATIONS'	CC	CP	NC	NNC
51 'GENERATING EQUATIONS FROM DESCR.'	CC	CP	NN	NNN
52 'SOLV. EQUA. FROM FACTORED FORM'	NN	CP	NN	NNN
53 'SOLVING QUAD.EQUAT.BY FACTORING '	NN	CP	NN	NNN
54 'SOLV. QUAD. EQUA. BY QUADRATIC '	NN	CP	NN	NNN
55 'GRAPHS OF QUADRATIC RELATIONS'	NN	CP	NN	NNC
56 'ONE UNKNOWN WITH NUM. COEFFI.'	NN	CP	NN	NNN
57 'SOLUT. OF QUADRATIC INEQUALITIES'	NN	CP	NC	NNN
58 'GRAPHING LIN. INEQ. IN ONE UNKNO'	NN	CP	NC	NNC
59 'SIMPLIF. OF A RATIONAL EXPRE.'	CC	CP	NC	NNC
60 'EVALUATION OF A RATIONAL EXPRE. '	CC	CP	NC	NNC
61 'ADD. & SUB. OF RATIONAL EXPRE.'	NN	CP	NC	NNC
62 'MUL. & DIV. OF RATIONAL EXPRE.'	NN	CP	NC	NNN
63 'PROBABILITY'	CC	CN	CC	NNN
64 'DESCRIPTIVE STATISTICS'	CC	CN	CC	NNN
65 'GRAPH READING'	NN	CC	CC	NCN
66 'LOCATI. OF POINTS IN CORD. PLANE'	NN	CC	CC	NCN
67 'DISTANCE BET. TWO POINTS IN COR.'	NN	CC	CC	NCC
68 'PERIMETER & AREA OF TRIANGLES,SQ'	NN	CC	CC	CCP
69 'CIRCUMFERENCE & AREA OF CIRCLE'	NN	NC	CC	CCP
70 'VOL. OF CUBES, CYLINDERS,RECTAN.'	NN	NC	CC	NNN
71 'FINDING SUM OF INTERIOR ANGLES'	CC	CC	NC	NCP
72 'ISOSCELES & EQUILATERAL TRIANGLE'	CC	CC	NN	NCP
73 'APPLIC. , CONGRUENT TRIANGLES'	NN	CC	NN	NCP
74 'APPLIC. , SIMPLE TRIANGLES'	NN	NC	NN	NCP
75 'PYTHAGOREAN THEOREM & SPECI. TR.'	CC	CC	NC	NCN
76 'PARALLELISM & PERPENDICULARITY'	CC	CC	NN	NCN
77 'PROOFS(FORMAL DEDUCTIVE DEMONST.'	NN	CC	NN	NNN
78 'TRANSFORMATIONS(TRANSLATION.'	NN	NN	NN	NNN
79 'VECTORS'	NN	NN	NN	NNN
80 'SIMPLIF. & EVALU. OF EXPRESS.'	NN	CP	NN	NNC
81 'SOLUTION OF EQUATIONS'	NN	CP	NN	NNC
82 'FUNCT. CONCEPT & USE OF NOTATION'	NN	CP	NN	NNN
83 'FUNCT. EVALUATION USING SUBSTIT.'	NN	CP	NN	NNN
84 'COMPOSITION OF FUNCTION'	NN	CP	NN	NNN
85 'GRAPHING OF FUNCTION'	NN	CP	NN	NNN
86 'NUMERICAL FUNCTIONALEVALUATION'	NN	NN	NN	NNN
87 'SUBSTITUTING LITERAL EXPRESS.'	NN	NN	NN	NNN
88 'DEFINITION, LAWS & RULES'	NN	NN	NN	NNN
89 'INVERSE RELATION BET. LOG. & EXP'	NN	NN	NN	NNN
90 'SOLUTION OF LOG. AND EXP. FUNCT.'	NN	NN	NN	NNN
91 'GRAPHING OF LOG. AND EXP. FUNCT.'	NN	NN	NN	NNN
92 'FIND. ALGEBRAIC EXPRESS'	NN	NN	NN	NNN
93 'DESCRIB. VARIATIONS OF FUNCTION '	NN	NN	NN	NNN
94 'FIND. SIDE LENGTHS IN SPEC.TRIA.'	NN	NC	NN	NNN
95 'GRAPHING TRIGONOMETRIC FUNCTIONS'	NN	NN	NN	NNN
96 'REDUCING TRIGONOMETRIC EXPRE.'	NN	NN	NN	NNN
97 'PROOF OF TRIGONOMETRIC IDENTITIE'	NN	NN	NN	NNN

APPENDIX C

TABLE C-1

ALGEBRA READINESS TEST MATH A (TEACHER 1) P-VALUES

ITEMS	1988	1989	'88-'89	CONTENT COVERAGE
1 'ADD. & SUB OF DECIMALS'	.346	.451	-.105	CP
2. 'MUL. & DIV. OF FRACTIONS'	.404	.549	-.145	CP
3. 'ADD. & SUB OF DECIMALS'	.596	.569	.027	CP
4. 'EVALUATION OF A POLYNOMIAL(1/2)'	.481	.549	-.068	CC
5. 'BASIC OPERATIONS WITH SIGNED NO.'	.654	.735	-.081	CP
6. 'GRAPH READING'	.173	.245	-.072	CC
7. 'BASIC OPERATIONS WITH SIGNED NO.'	.404	.520	-.116	CP
8. 'BASIC OPERATIONS WITH SIGNED NO.'	.654	.686	-.032	CP
9. 'FINDING DISTANCES ON NUMBER LINE'	.462	.520	-.058	CC
10.'COMPUTATION OF PERCENT'	.365	.431	-.066	CP
11 'MUL. & DIV. OF FRACTIONS'	.385	.431	-.046	CP
12 'PRIME FACTORIZATION'	.250	.186	.064	CC
13 'ONE UNKNOWN WITH NUM. COEFFI.'	.481	.569	-.088	CC
14 'ONE UNKNOWN WITH NUM. COEFFI.'	.538	.578	-.040	CC
15 'EVALUATION OF A POLYNOMIAL(1/2)'	.538	.588	-.050	CC
16 'MUL. & DIV. OF FRACTIONS'	.250	.363	-.113	CP
17 'MUL. & DIV. OF DECIMALS'	.519	.490	.029	CP
18.'ADD. & SUB. OF FRACTIONS'	.250	.179	.074	CP
19 'MUL. & DIV. OF FRACTIONS'	.327	.275	.052	CP
20 'PRIME FACTORIZATION'	.385	.353	.032	CC
21 'BASIC OPERATIONS WITH SIGNED NO.'	.173	.173	.026	CP
22 'BASIC OPERATIONS WITH SIGNED NO.'	.231	.255	-.024	CP
23 'SQ. ROOT OF PERFECT SQUARES'	.231	.294	-.063	CC
24 'EVALUATION OF A POLYNOMIAL(1/2)'	.269	.245	.024	CC
25 'MUL. & DIV. OF DECIMALS'	.346	.431	-.085	CP
26 'CONV. BET. FRACTIONS & PERCENT'	.308	.245	.063	CP
27 'BASIC OPERATIONS WITH SIGNED NO.'	.192	.333	-.141	CP
28 'SIMPLIF. OF A RATIONAL EXPRE.'	.423	.324	.099	NC
29 'MUL. & DIV. OF FRACTIONS''	.365	.235	.130	CP
30 'APPLIC. OF RATIO OR PROPORTIONS'	.288	.314	-.026	CC
31 'SIMPLIF. OF COMPLEX FRACTIONS'	.192	.373	-.181	CP
32.'ESTIMATION & APPROXIMATION'	.404	.500	-.096	CP
33 'ALGE OPERATION OF LITERAL SYMBOL'	.135	.127	.008	CC
34 'EXPONENT. WITH INTEGRAL EXPONEN.'	.231	.118	.113	CC
35 'FINDING DISTANCES ON NUMBER LINE'	.231	.314	-.083	CC
36.'LOCATI. OF POINTS IN CORD. PLANE'	.212	.373	-.161	CC
37.'ORDER & COMPARISON OF FRACTIONS'	.173	.147	.026	CP
38.'PERIMETER & AREA OF TRIANGLES, SQ'	.288	.284	.004	CC
39.'PYTHAGOREAN THEOREM & SPECI. TR.'	.096	.216	-.120	NC
40.'POWERS OF 10 & SCIENTIFIC NOTAT.'	.231	.324	-.093	CC
41.'ORDER & COMPARISON OF FRACTIONS'	.231	.284	-.053	CP
42.'ADD. & SUB. OF FRACTIONS'	.058	.098	-.040	CP
43.'ADD. & SUB. OF FRACTIONS'	.038	.118	-.080	CP
44.'COMPUTATION OF PERCENT'	.115	.147	-.032	CP
45.'COMPUT. WITH DECI & FRAC, ROUND.'	.269	.196	.073	CP
46.'CIRCUMFERENCE & AREA OF CIRCLE'	.115	.147	-.032	CC
47.'BASIC OPERATIONS WITH SIGNED NO.'	.212	.255	-.043	CP
48.'SQ. ROOT OF PERFECT SQUARES'	.096	.137	-.041	CC
49.'PERIMETER & AREA OF TRIANGLES, SQ'	.115	.167	-.052	CC
50.'APPLIC., SIMPLE TRIANGLES'	.173	.147	.026	NC

TABLE C - 2

ALGEBRA READINESS TEST PRE-ALGEBRA (TEACHER 14) P-VALUES

ITEMS	1988	1989	'88-'89	CONTENT COVERAGE
1 'ADD. & SUB OF DECIMALS'	.455	.600	-.145	CC
2. 'MUL. & DIV. OF FRACTIONS'	.782	.800	-.018	CC
3. 'ADD. & SUB OF DECIMALS'	.764	.711	.053	CC
4. 'EVALUATION OF A POLYNOMIAL(1/2)'	.527	.600	-.073	NC
5. 'BASIC OPERATIONS WITH SIGNED NO.'	.800	.844	-.044	CC
6. 'GRAPH READING'	.327	.244	.083	NC
7. 'BASIC OPERATIONS WITH SIGNED NO.'	.436	.644	-.208	CC
8. 'BASIC OPERATIONS WITH SIGNED NO.'	.636	.667	-.031	CC
9. 'FINDING DISTANCES ON NUMBER LINE'	.600	.689	-.089	NC
10. 'COMPUTATION OF PERCENT'	.545	.467	.078	CC
11 'MUL. & DIV. OF FRACTIONS'	.709	.622	.087	CC
12 'PRIME FACTORIZATION'	.455	.489	-.034	CC
13 'ONE UNKNOWN WITH NUM. COEFFI.'	.709	.644	.065	NN
14 'ONE UNKNOWN WITH NUM. COEFFI.'	.600	.733	-.133	NN
15 'EVALUATION OF A POLYNOMIAL(1/2)'	.564	.667	-.103	NC
16 'MUL. & DIV. OF FRACTIONS'	.345	.356	-.011	CC
17 'MUL. & DIV. OF DECIMALS'	.527	.600	-.073	CC
18. 'ADD. & SUB. OF FRACTIONS'	.364	.400	-.036	CC
19 'MUL. & DIV. OF FRACTIONS'	.400	.333	.067	CC
20 'PRIME FACTORIZATION'	.600	.644	-.044	CC
21 'BASIC OPERATIONS WITH SIGNED NO.'	.364	.289	.075	CC
22 'BASIC OPERATIONS WITH SIGNED NO.'	.291	.244	.047	CC
23 'SQ. ROOT OF PERFECT SQUARES'	.164	.267	-.103	NC
24 'EVALUATION OF A POLYNOMIAL(1/2)'	.291	.200	.091	NC
25 'MUL. & DIV. OF DECIMALS'	.236	.378	-.142	CC
26 'CONV. BET. FRACTIONS & PERCENT'	.764	.711	.053	CC
27 'BASIC OPERATIONS WITH SIGNED NO.'	.309	.356	-.047	CC
28 'SIMPLIF. OF A RATIONAL EXPRE.'	.364	.289	.075	NN
29 'MUL. & DIV. OF FRACTIONS''	.273	.244	.029	CC
30 'APPLIC. OF RATIO OR PROPORTIONS'	.309	.444	-.135	CC
31 'SIMPLIF. OF COMPLEX FRACTIONS'	.236	.333	-.097	CC
32. 'ESTIMATION & APPROXIMATION'	.364	.467	-.103	CC
33 'ALGE OPERATION OF LITERAL SYMBOL'	.073	.044	.029	CC
34 'EXPONENT. WITH INTEGRAL EXPONEN.'	.145	.244	-.099	NC
35 'FINDING DISTANCES ON NUMBER LINE'	.273	.378	-.105	NC
36. 'LOCATI. OF POINTS IN CORD. PLANE'	.182	.333	-.151	NC
37. 'ORDER & COMPARISON OF FRACTIONS'	.164	.200	-.036	CC
38. 'PERIMETER & AREA OF TRIANGLES, SQ'	.218	.200	.018	CC
39. 'PYTHAGOREAN THEOREM & SPECI. TR.'	.200	.133	.140	CC
40. 'POWERS OF 10 & SCIENTIFIC NOTAT.'	.273	.133	-.093	CC
41. 'ORDER & COMPARISON OF FRACTIONS'	.145	.044	.101	CC
42. 'ADD. & SUB. OF FRACTIONS'	.055	.133	-.078	CC
43. 'ADD. & SUB. OF FRACTIONS'	.036	.067	-.031	CC
44. 'COMPUTATION OF PERCENT'	.073	.044	.029	CC
45. 'COMPUT. WITH DECI & FRAC, ROUND.'	.182	.178	.004	CC
46. 'CIRCUMFERENCE & AREA OF CIRCLE'	.073	.067	.006	CC
47. 'BASIC OPERATIONS WITH SIGNED NO.'	.055	.111	-.056	CC
48. 'SQ. ROOT OF PERFECT SQUARES'	.073	.044	.029	NC
49. 'PERIMETER & AREA OF TRIANGLES, SQ'	.055	.044	.011	CC
50. 'APPLIC., SIMPLE TRIANGLES'	.073	.044	.029	CC

TABLE C - 3

ALGEBRA READINESS TEST LOWER THAN PRE-ALGEBRA (TEACHER 17) P-VALUES

ITEMS	1988	1989	'88-'89	CONTENT COVERAGE
1 'ADD. & SUB OF DECIMALS'	.400	.368	.032	CP
2. 'MUL. & DIV. OF FRACTIONS'	.600	.588	.012	CP
3. 'ADD. & SUB OF DECIMALS'	.360	.485	-.125	CP
4. 'EVALUATION OF A POLYNOMIAL(1/2)'	.320	.375	-.055	NN
5. 'BASIC OPERATIONS WITH SIGNED NO.'	.600	.684	-.084	CC
6. 'GRAPH READING'	.160	.184	-.024	CC
7. 'BASIC OPERATIONS WITH SIGNED NO.'	.320	.588	.172	CC
8. 'BASIC OPERATIONS WITH SIGNED NO.'	.760	.667	-.031	CC
9. 'FINDING DISTANCES ON NUMBER LINE'	.400	.493	-.093	CC
10. 'COMPUTATION OF PERCENT'	.760	.449	.311	CP
11 'MUL. & DIV. OF FRACTIONS'	.560	.390	.170	CP
12 'PRIME FACTORIZATION'	.520	.316	.204	CC
13 'ONE UNKNOWN WITH NUM. COEFFI.'	.480	.529	-.049	NN
14 'ONE UNKNOWN WITH NUM. COEFFI.'	.640	.537	.103	NN
15 'EVALUATION OF A POLYNOMIAL(1/2)'	.400	.500	-.100	NN
16 'MUL. & DIV. OF FRACTIONS'	.200	.279	-.079	CP
17 'MUL. & DIV. OF DECIMALS'	.320	.485	-.165	CP
18. 'ADD. & SUB. OF FRACTIONS'	.240	.309	-.069	CP
19 'MUL. & DIV. OF FRACTIONS'	.400	.360	.040	CP
20 'PRIME FACTORIZATION'	.560	.485	.075	CC
21 'BASIC OPERATIONS WITH SIGNED NO.'	.320	.250	.070	CC
22 'BASIC OPERATIONS WITH SIGNED NO.'	.200	.228	.028	CC
23 'SQ. ROOT OF PERFECT SQUARES'	.080	.279	-.199	NC
24 'EVALUATION OF A POLYNOMIAL(1/2)'	.280	.272	.008	NN
25 'MUL. & DIV. OF DECIMALS'	.360	.404	-.044	CP
26 'CONV. BET. FRACTIONS & PERCENT'	.480	.441	.039	CP
27 'BASIC OPERATIONS WITH SIGNED NO.'	.240	.287	-.047	CC
28 'SIMPLIF. OF A RATIONAL EXPRE.'	.280	.382	-.102	NN
29 'MUL. & DIV. OF FRACTIONS''	.200	.346	-.146	CP
30 'APPLIC. OF RATIO OR PROPORTIONS'	.360	.287	.073	PP
31 'SIMPLIF. OF COMPLEX FRACTIONS'	.240	.316	-.076	CP
32. 'ESTIMATION & APPROXIMATION'	.280	.419	-.139	CC
33 'ALGE OPERATION OF LITERAL SYMBOL'	.120	.074	.046	NN
34 'EXPONENT. WITH INTEGRAL EXPONEN.'	.200	.478	-.278	CP
35 'FINDING DISTANCES ON NUMBER LINE'	.320	.221	.099	CC
36. 'LOCATI. OF POINTS IN CORD. PLANE'	.320	.316	.004	CC
37. 'ORDER & COMPARISON OF FRACTIONS'	.320	.169	.151	CP
38. 'PERIMETER & AREA OF TRIANGLES, SQ'	.240	.338	-.098	CC
39. 'PYTHAGOREAN THEOREM & SPECI. TR.'	.160	.206	-.046	NC
40. 'POWERS OF 10 & SCIENTIFIC NOTAT.'	.280	.368	-.088	CP
41. 'ORDER & COMPARISON OF FRACTIONS'	.080	.287	-.207	CP
42. 'ADD. & SUB. OF FRACTIONS'	.040	.162	-.122	CP
43. 'ADD. & SUB. OF FRACTIONS'	.000	.096	-.096	CP
44. 'COMPUTATION OF PERCENT'	.080	.118	-.038	CP
45. 'COMPUT. WITH DECI & FRAC, ROUND.'	.120	.206	-.086	CC
46. 'CIRCUMFERENCE & AREA OF CIRCLE'	.080	.103	-.023	CC
47. 'BASIC OPERATIONS WITH SIGNED NO.'	.080	.272	-.192	CC
48. 'SQ. ROOT OF PERFECT SQUARES'	.080	.125	-.045	NC
49. 'PERIMETER & AREA OF TRIANGLES, SQ'	.000	.169	-.169	CC
50. 'APPLIC., SIMPLE TRIANGLES'	.080	.213	-.133	CC

TABLE C - 4

ELEMENTARY ALGEBRA TEST ALGEBRA I (TEACHER 4) P-VALUES

ITEMS	1988	1989	'88-'89	CONTENT COVERAGE
1 'ADD. & SUB OF DECIMALS'	.963	1.000	-.037	CC
2. 'MUL. & DIV. OF FRACTIONS'	.963	.950	.013	CC
3. 'ADD. & SUB OF DECIMALS'	.407	.500	-.193	CC
4. 'EVALUATION OF A POLYNOMIAL(1/2)'	.741	.700	.041	CC
5. 'BASIC OPERATIONS WITH SIGNED NO.'	.827	.700	.127	CP
6. 'GRAPH READING'	.914	.800	.114	CC
7. 'BASIC OPERATIONS WITH SIGNED NO.'	.420	.300	.120	NC
8. 'BASIC OPERATIONS WITH SIGNED NO.'	.531	.550	-.019	CC
9. 'FINDING DISTANCES ON NUMBER LINE'	.563	.900	.063	CC
10. 'COMPUTATION OF PERCENT'	.642	.550	.092	CC
11 'MUL. & DIV. OF FRACTIONS'	.679	.500	.179	CC
12 'PRIME FACTORIZATION'	.864	.700	.164	CC
13 'ONE UNKNOWN WITH NUM. COEFFI.'	.815	.750	.065	CC
14 'ONE UNKNOWN WITH NUM. COEFFI.'	.901	.700	.201	CC
15 'EVALUATION OF A POLYNOMIAL(1/2)'	.963	1.000	-.037	CC
16 'MUL. & DIV. OF FRACTIONS'	.654	.800	-.146	CC
17 'MUL. & DIV. OF DECIMALS'	.852	.600	.252	CC
18. 'ADD. & SUB. OF FRACTIONS'	.580	.700	-.120	NC
19 'MUL. & DIV. OF FRACTIONS'	.679	.600	.079	CC
20 'PRIME FACTORIZATION'	.963	.900	.063	CC
21 'BASIC OPERATIONS WITH SIGNED NO.'	.457	.600	-.143	CC
22 'BASIC OPERATIONS WITH SIGNED NO.'	.864	.800	.064	CC
23 'SQ. ROOT OF PERFECT SQUARES'	.901	.800	.101	CC
24 'EVALUATION OF A POLYNOMIAL(1/2)'	.778	.700	.078	CC
25 'MUL. & DIV. OF DECIMALS'	.864	.950	-.086	CC
26 'CONV. BET. FRACTIONS & PERCENT'	.728	.750	-.022	CC
27 'BASIC OPERATIONS WITH SIGNED NO.'	.926	1.000	-.074	CC
28 'SIMPLIF. OF A RATIONAL EXPRE.'	.901	.900	.001	CC
29 'MUL. & DIV. OF FRACTIONS''	.741	.700	.041	CC
30 'APPLIC. OF RATIO OR PROPORTIONS'	.753	.750	.003	CC
31 'SIMPLIF. OF COMPLEX FRACTIONS'	.728	.750	-.022	CC
32. 'ESTIMATION & APPROXIMATION'	.309	.400	-.091	CC
33 'ALGE OPERATION OF LITERAL SYMBOL'	.753	.700	.053	CC
34 'EXPONENT. WITH INTEGRAL EXPONEN.'	.704	.550	-.154	CC
35 'FINDING DISTANCES ON NUMBER LINE'	.728	.550	.078	CC
36. 'LOCATI. OF POINTS IN CORD. PLANE'	.654	.600	.054	CC
37. 'ORDER & COMPARISON OF FRACTIONS'	.827	.800	.027	CC
38. 'PERIMETER & AREA OF TRIANGLES, SQ'	.765	.600	.165	CC
39. 'PYTHAGOREAN THEOREM & SPECI. TR.'	.617	.600	.017	CC
40. 'POWERS OF 10 & SCIENTIFIC NOTAT.'	.667	.450	.217	CC
41. 'ORDER & COMPARISON OF FRACTIONS'	.469	.450	.019	NN
42. 'ADD. & SUB. OF FRACTIONS'	.531	.500	.031	NN
43. 'ADD. & SUB. OF FRACTIONS'	.272	.450	-.178	CC
44. 'COMPUTATION OF PERCENT'	.741	.550	.191	CC
45. 'COMPUT. WITH DECI & FRAC, ROUND.'	.481	.400	.081	CC
46. 'CIRCUMFERENCE & AREA OF CIRCLE'	.198	.150	.048	NN
47. 'BASIC OPERATIONS WITH SIGNED NO.'	.519	.350	.169	CC
48. 'SQ. ROOT OF PERFECT SQUARES'	.741	.500	.241	CC
49. 'PERIMETER & AREA OF TRIANGLES, SQ'	.481	.450	.031	CC
50. 'APPLIC., SIMPLE TRIANGLES'	.306	.350	.136	CC

TABLE C - 5

ELEMENTARY ALGEBRA TEST ALGEBRA I (TEACHER 14) P-VALUES

ITEMS	1988	1989	'88-'89	CONTENT COVERAGE
1 'SIMPLIF. OF POLYNO. BY GROUPING'	.542	.615	-.073	CC
2. 'CONV. BET. FRACTIONS & DECIMALS'	.854	.692	.162	PP
3. 'ESTIM. & APPROXI. WITH RADICALS.'	.042	.038	.004	NN
4. 'EXPONENT. WITH INTEGRAL EXPONEN.'	.312	.538	-.226	CC
5. 'ADD. & SUB OF DECIMALS'	.312	.500	-.188	PP
6. 'SQUARING A BINOMIAL'	.396	.654	-.258	CC
7. 'ISOSCELES & EQUILATERAL TRIANGLE'	.187	.231	-.044	PP
8. 'EXPONENT. WITH INTEGRAL EXPONEN.'	.104	.000	.104	CC
9. 'LOCATI. OF POINTS IN CORD. PLANE'	.604	.615	-.011	CN
10. 'SIMPLIF. OF A RATIONAL EXPRE.'	.437	.615	-.178	CC
11 'SOLV. EQUA. FROM FACTORED FORM'	.229	.577	-.348	NN
12 'MUL. OF MONOMIAL WITH A POLYNO.	.625	.577	.048	CC
13 'FACTOR. TRINOMIAL OVER INTEGERS'	.437	.385	.052	CC
14 'ONE UNKNOWN WITH NUM. COEFFI.'	.437	.462	-.025	CC
15 'EVALUATION OF A POLYNOMIAL(1/2)'	.687	.615	.072	PP
16 'TWO UNKNOWN BY ELIMINATION'	.083	.115	-.032	CN
17 'SQ. ROOT OF PERFECT SQUARES'	.271	.231	.040	NN
18. 'PYTHAGOREAN THEOREM & SPECI. TR.'	.562	.577	-.015	NN
19 'MUL. & DIV. OF FRACTIONS'	.229	.385	-.156	PP
20 'GRAPHING LIN. INEQ. IN ONE UNKNOWN'	.417	.462	-.045	CN
21 'COMPUTATION OF PERCENT'	.146	.154	-.008	CP
22 'ADD. & SUB. OF SQ.ROOTS'	.062	.077	-.015	NN
23 'FACTOR, PERFECT SQ. TRINOMIALS'	.417	.846	-.429	CC
24 'MUL. & DIV. OF SQ. ROOTS'	.167	.385	-.218	NN
25 'APPLICATION OF EQUATIONS'	.417	.269	.148	CC
26 'ONE UNKNOWN WITH NUM. COEFFI.'	.146	.115	.031	CC
27 'EVALUATION OF RATIONAL EXPRE.'	.396	.538	-.142	CC
28 'SIMPLIF. OF SQUARE ROOTS'	.062	.154	-.092	NN
29 'ADD. & SUB. OF POLYNOMIALS'	.167	.269	-.102	CC
30 'SIMPLIF. OF RATIONAL EXPRE.'	.354	.538	-.184	CC
31 'PERIMETER & AREA OF TRIANGLES, SQ'	.125	.346	-.221	CP
32. 'PERIMETER & AREA OF TRIANGLES, SQ'	.229	.462	-.233	CP
33 'SIMPLIF. OF A RATIONAL EXPRE.'	.250	.346	-.096	CC
34 'ONE UNKNOWN WITH NUM. COEFFI.'	.104	.077	.027	CC
35 'MUL. & DIV. OF RATIONAL EXPRE.'	.271	.462	-.191	CC
36. 'ONE UNKNOWN WITH NUM. COEFFI.'	.162	.077	-.015	CC
37. 'TWO UNKNOWN BY SUBSTITUTION'	.104	.115	-.011	CN
38. 'POWERS OF 10 & SCIENTIFIC NOTAT.'	.125	.346	-.221	CC
39. 'SOLVING QUAD. EQUAT. BY FACTORING'	.104	.192	-.088	NN
40. 'ADD. & SUB. OF RATIONAL EXPRE.'	.042	.269	-.227	CC
41. 'VOL. OF CUBES, CYLINDERS, RECTAN.'	.146	.308	-.162	NN
42. 'APPLIC., SIMPLE TRIANGLES'	.229	.462	-.233	PP
43. 'FINDING DISTANCES ON NUMBER LINE'	.042	.077	-.035	CP
44. 'ONE UNKNOWN WITH LIT. COEFFI.'	.062	.115	-.053	CC
45. 'COMPUTATION OF PROPORTIONS'	.021	.038	-.017	CP
46. 'CIRCUMFERENCE & AREA OF CIRCLE'	.021	.038	-.017	PP
47. 'SOLVING QUAD. EQUAT. BY FACTORING'	.104	.346	-.242	NN
48. 'ONE UNKNOWN WITH NUM. COEFFI.	.021	.308	-.287	CC
49, 'ONE UNKNOWN WITH NUM. COEFFI.	.062	.385	-.323	CC
50. 'SOLV. QUAD. EQUA. BY QUADRATIC'	.021	.154	-.133	NN

Conceptual Considerations in Instructionally Sensitive Assessment

Leigh Burstein

The Instructional Assessment Project has been conducted at the Center for Research on Evaluation, Standards, and Student Testing (CRESST) under a grant from the Office of Educational Research and Improvement (OERI). The overall goals of the project are (1) to improve the validity of subject matter tests and (2) to improve the instructional sensitivity of psychometric and statistical methods used to analyze, interpret, and report test data intended to guide instructional and curriculum decision-making. The work is intended to contribute to improvements in the conceptual and technical foundations of instructionally sensitive assessment within the context of large-scale achievement testing.

The project's conceptual and analytical studies draw upon secondary analyses of U.S. data from the Second International Mathematics Study (SIMS; Burstein, et al., in progress; McKnight, et al., 1987; Robitaille and Garden, 1989; Travers & Westbury, 1989). In 1981-82, 180 mathematics achievement items were administered on two occasions (near the beginning and end of the school year) to students in over 200 8th grade mathematics classes (remedial, typical, enriched, algebra) which varied considerably in opportunity to learn the topics covered in the test, use of textbooks, and use of a variety of teaching styles. The SIMS data set is unusually rich in its set of teacher-reported information about classroom activities, including item-specific opportunity to learn information. Overall, this data set incorporates the kinds and range of information deemed necessary to develop and investigate models

of student knowledge/ability as a consequence of their instructional experiences.

This paper describes the conceptual framework for instructionally sensitive assessment that guided the analyses of data from the Second International Mathematics Study (SIMS). Both the intellectual rationale for the project effort and the current version of the guiding conception of "instructionally sensitive psychometrics" are discussed. The paper also considers briefly certain practical realities derived from our experiences in analyzing SIMS thus far and possible implications for applications of the methodology in other large-scale achievement contexts.

Instructional Assessment

Testing has played a major role in the many educational reforms that have been enacted throughout the country in the past few years (Linn, 1987; Pipho, 1985). Clearly, policymakers expect that new test requirements will provide a mechanism for improving instruction and student learning. As Petrie (1987) has put it, tests are the "engines of educational reform" (p. 1).

The contrast between these expectations and the views of many classroom teachers and educational researchers about the value of tests for improving instructional decisions is stark. Many teachers find that standardized tests provide them with little diagnostic information that can be used to improve their

instructional decisions. There is also a paucity of research evidence supporting the claim that tests provide valid diagnostic information or the notion that test results have improved the day-to-day decision-making in the classroom (Baker, 1987; Baker & Herman, 1986; Bejar, 1984; Burstein, 1983; Glaser, 1986; Linn, 1986).

There are, of course, many reasons for the contrasting perspectives about the value of tests in improving instruction and student learning. To begin with, the perspectives, while quite different, are not necessarily contradictory. Tests that have been introduced in most of the reform legislation need not provide diagnostic information or influence day-to-day decision-making in order to affect teaching and learning. When important consequences are perceived to be attached to test results, the tests can have a major influence over topic coverage and emphasis (see, for example, Airasian & Madaus, 1983; Linn, 1988). The change in emphasis can create a better match between what is taught and what is tested, and, as a consequence, affect test performance (Cooley & Leinhardt, 1980; Leinhardt, 1983; Leinhardt & Seewald, 1981).

Policymakers rightly assume that test requirements can lead to other educational changes that, in turn, produce changes in student performance. The required tests send a clear message to teachers about what is considered important, and thereby shape the curriculum. They can do this, however, without teachers using the test results of individual pupils to make instructional decisions. The potential of tests to serve the

latter function is largely unrealized. How and, indeed whether, testing systems can be devised that contribute to instruction and student learning in this way remain important, but largely unanswered questions that are the focus of the Instructional Assessment project.

The work reported here is concerned with the improvement of the instructional sensitivity of psychometric and statistical methods used to analyze, interpret, and report test data intended to guide instructional decisions. Work already completed on the project suggests a number of important factors which influence the validity of the use of test results for instructional decisions and instructional sensitivity of the tests (Burstein, Webb, Muthén, & Linn, 1987).

First, it is evident that there are multiple, systematic factors that contribute to student performance as measured by an instructional assessment at a given point in time. In order for such measurements to effectively aid in instructional improvement, they must be designed, analyzed, and reported in ways that distinguish among the factors (student ability, topic exposure, forms of instructional exposure) that affect performance (Burstein, Chen, Sen & Kim, 1987; Muthén, Kao & Burstein, 1987; Shavelson, Webb, Shemesh & Yang, 1988). Otherwise the validity of the assessment for the purposes it is intended to serve is likely to be compromised or weakened. For example, it is a waste of resources to attempt individually-targeted remediation when the basis for a particular diagnostic signal is lack of exposure to the knowledge and skills assessed.

Second, auxiliary information about characteristics of the students and their instructional experiences are essential to properly utilizing appropriately designed instructional assessments. Student characteristic data can serve various purposes. Prior ability and performance data can help distinguish learning within a given setting and whether students from all levels benefit proportionately or otherwise. Gender, ethnicity, and other socio-demographic information allow the possibility of monitoring equity considerations. The effort to remedy the social and structural conditions that allow these factors to influence educational opportunities and, hence, performance requires a conscious attempt to monitor these factors in instructional assessment efforts.

With respect to instructional experiences, minimally, the ability to distinguish among the different educational settings (classes and schools) in which assessments are administered is a necessary condition for an appropriate interpretation of student performance data. Information about actual topic coverage and instructional methods are of even greater value.

Third, it is clear that the psychometric models and statistical analyses that have served traditional goals of measuring individual differences for purposes of prediction, are, at best, incomplete for purposes of identifying the instructional factors which influence performance on specific problems, identifying item content and process characteristics that are most sensitive to instructional practices, and the maximization of the instructional utility of achievement test

results. Analytic procedures that incorporate information about student background, prior instructional experiences, item content, and the cognitive processes involved in answering questions (e.g., Muthén, et al., 1988) are needed.

Fourth, beyond better analytic methods, there is a need for a better understanding of test items themselves. Among the pertinent questions in this are the influences of both alternative representations of problems and alternative forms of response on student cognitive processes and performance levels (Webb & Shavelson, 1987; Shavelson, et al., 1988).

The issues highlighted are that appropriate models for student performance and proper contextualization through the collection of auxiliary information about students and their instructional programs are essential in the design, analysis and interpretation of multipurpose instructional assessments. Results from instructional assessments reflect both demographic and ability attributes of the students and the instructional intents, opportunities, and execution of the settings in which students reside; moreover, these accrue and change over time. Thus one needs to be cognizant of these circumstances and sensitive to their consequences for the validity of test interpretations.

One implication from the analytical techniques applied thus far is that it is important not to value complexity of analytical methods for their own sake in validating and applying instructional assessments. Sensitivity to the nature of the substantive processes that underlie performance and the

educational structure within which instruction takes place should be the primary criterion for judging the appropriateness and utility of analytical methods (Burstein, 1980, 1983; 1984, 1986; Shavelson, Webb, & Burstein, 1986; Sirotnik & Burstein, 1986). Contrary to what one might surmise from the prevailing literature, this is especially true when the focus of the assessment is to guide instructional improvement rather than to contribute to the educational research knowledge base.

Another point that comes through is the value of collecting assessment and accompanying characteristic data longitudinally. Benefits that accrued from the two measurement occasions in SIMS compared with the single cross-sectional data collection in other major national and international educational surveys are well documented (e.g., Burstein, et al. , in press; Kifer, Schmidt & Wolfe, 1984, in press; Delandshere, 1986; Muthén, et al., 1987, Wolfe, 1986).

What is common to the analytical methods employed thus far in our own investigations is their use for analyzing <u>patterns</u> of performance. Whether one is dealing with a set of items designed to represent different topics or ways of understanding, or with students differentiated by their demographic attributes or the attributes of the instructional histories or with performance on a single measurement over time, it is important that the analysis methods mirror to the extent possible the structure of the educational situation. For example, if students in Algebra class A are not taught simple formulas at all, students in class B are taught using only symbolic

manipulations of algebraic equations (e.g., if P=LW, and L=2 and P=6, what is W), and students in class C receive instruction that also embed the formula within real situations (e.g., word problems with and without accompanying pictorial representations), one would want a test designed to reflect the distinctions in the classes's experiences and an analysis that will detect these distinctions with sufficient specificity to point to areas of needed instructional improvement. And, presuming no prior introduction to the topic, one would want to employ analytical methods that associate performance patterns with class-level instructional differences rather than imply that student attributes are responsible for the differences.

Again, taking the studies as a set, certain characteristics of methodology that influence the validity of the design, analysis, and interpretation of instructional assessments are evident. First, analysis strategies that are sensitive to data structure are essential. These may be simple techniques but their use should follow a comprehensive conception of student performance in educational and social contexts within the course of their schooling. A corollary of the first point is that analyses of data only in the form of highly aggregated scores (total scores representing horizontal aggregations performance across topics and ways of understanding) and at only a single educational level (whether students only or at some level of vertical aggregation to classes, courses or course sequences, schools, districts, and so forth) are unlikely to be sufficiently informative to guide instructional improvement.

Analyses, like designs, need to be multifaceted and multi-dimensional since attributes of any given performance certainly are.

"Instructionally Sensitive Psychometrics"

To gain some perspective on our approach to instructional sensitivity, it is useful to contrast our conception with one more prevalent in traditional psychometric practice. As a starting point, we argue that whether classical or modern (IRT), conventional psychometric analyses of educational achievement data, guided by a concern for valid measurement of individual differences in ability constructs, typically leave little room for capturing the complexity of educational experiences of students within naturally occurring educational settings.

Contrasting views about the relationship of the "experiences a student has" and "his/her performance/ achievement/ability" is central to distinguishing traditional conceptions from our own. Traditionally, instructionally sensitive psychometric methods are those which lead to better student-level diagnoses. The focus is clearly on the "ability" attribute, a property of the individual student at some point in time. One is not concerned about how individual differences got to be the way they are but rather whether the assessment, and its accompanying analyses, lead to accurate and efficient diagnoses of individuals' levels of functioning on given achievement/ability constructs.

Our work has approached this problem from the opposite direction. That is, while we want to validly measure ability/achievement constructs and individual differences therein, our primary concern is on how ability/achievement measures reflect educational and other experiences, or, in other words, on tests/assessments as measures of instruction/schooling/education. We are concerned not only with improving assessment of what students know but also with how differences in what they know come about from educational experiences. In other words, we approach testing/assessment from the instruction side rather than the abilities (the nature of knowledge) side.

Adopting our conception would mean that one's model of a student response to a specific test item has to include components having to do with ability attributes and experience attributes, broadly conceived, plus task characteristic attributes and how they interact with the other two types of attributes. How this falls out in a given assessment situation, then, can get quite complex, but some of the issues are clear.

1. A primary purpose for instructionally sensitive assessments is to reflect student knowledge/ability as the consequence of instruction. Whether the specific case is educational effects/school effectiveness research, traditional policy analysis about educational productivity, indicators of educational achievement, or more accountability driven measurement, the quality of the assessment is directly related to the degree that it comprehensively reflects student

knowledge/ability at some point in the course of their education/schooling.

2. Within a subject matter, appropriate assessment would invariably require the measurement of multiple dimensions (components) of knowledge/ability. These dimensions/components may entail finer distinctions in representing the topics in subject matter (algebra, geometry) but clearly must also reflect the processes required to perform the specific tasks required by individual test items (e.g., conceptual knowledge, procedural knowledge, a variety of complex thinking skills such as integration of tasks, symbol system flexibility).

3. Each test item reflects multiple components pertinent to the purposes of the assessment. Unfortunately, it also taps components (e.g., reading ability, motivation, test taking strategy) that are likely to be irrelevant to the judgement about a student's status on the targeted assessment dimensions. Desirable analytical models allow one to assess performance on the desired dimensions and to separate out the irrelevant components.

4. Both content exposure/opportunity to learn and the ways in which students have been taught matter. Instructionally sensitive assessment and analysis technology should detect which students receive more comprehensive exposure and emphases with respect to ability/achievement/knowledge domains of interest. There are "better ways" to teach a topic, but these better ways may depend on individual differences in learning preferences. In the absence of a clear identification of a uniformly best

method, instruction that casts the broadest net in introducing ideas is better.

5. Ideally, instructionally sensitive assessments should validly indicate when a particular constellation of educational experiences at the level of interest (student, learning group, class, school, district, state, nation) has achieved the standard of performance judged to be acceptable/essential/good. This conception could refer to a functional literacy standard, an expert standard, or whatever.

6. With respect to any specific outcome domain, the means of presentation of an item and its response format are distinguishable from the underlying attribute. For example, to say that a student "understands" or has "mastered" proportionate reasoning, we mean that regardless of the form of representation of the problem or the mode of response, the student has a high probability of answering a question on the topic correctly.

7. Because students differ in their learning preferences and prior learning experiences, and students (and thus most likely, their learning preferences and prior knowledge/abilities/achievements) are not randomly allocated to/distributed among educational settings, there is a need to distinguish between status/knowledge and progress/learning. Whether educational units should be given "credit" for their students' status/knowledge is unclear (conceivably the units still foster retention or prevent regress) but certainly progress/learning should be properly credited. Developmentalists might be inclined to argue that to credit

institutions for the developmental growth is inappropriate but this is really an argument for building a model of "natural development" into one's analysis rather than to discount educational experiences.

Analytically, the implied emphasis on progress/learning means that background attributes of students need to be included in analytical methods (both additively and interactively). If the desired outcomes and their standards are sufficiently comprehensive, however, there should be no problem in crediting institutions for both the proportion of their students who have met the standards and for progress in the direction of achieving standards.

8. Instructionally sensitive psychometrics should distinguish teaching the content domains of interest from "teaching to the test". Specific sensitivity to content irrelevant to the attributes one is trying to measure reflects a form of item bias. In other words, our interest in whether a student knows the specific concept "acute angle" depends on how well knowledge of this concept represents his/her knowledge of the "language" of the properties of triangles. Content exposure effects on specific item performance is undesirable IF one has adequately represented the main dimensions/components reflected in the latent ability/achievement structure. Such effects could reflect "teaching to the specific items contained on an assessment" as opposed to other items that might have been sampled. Approaching the question differently, one wants to

discount performance to the degree it reflects specific teaching to the specific item.

Our notion of instructional sensitivity positively values two kinds of opportunity to learn (OTL) effects. The first kind is that general content exposure to a certain topic or of a certain type (e.g., computation, work with word problems) should affect the latent ability/achievement components of interest. This should occur because some teachers teach topics that others don't (topics, not items or narrow concepts) and some teachers emphasize certain ways of teaching topics that others don't.

The second kind of valuable OTL is when the teaching of a specific concept/strategy is particularly synergistic, operating as a "gatekeeper" (once a student understand this idea, the whole picture unfolds). Such ideas/concepts/strategies capture broader understandings and representations that capture broader understandings. In this case, presuming that such key ideas/concepts/strategies existed, opportunity to learn such entities should directly affect corresponding ability/achievement components.

With the first kind of valued OTL, one would want to have effects from content over the set of items representing the topic or method affecting the ability/achievement components which tap these attributes. Some form of compositing improves the measurement properties of the OTL measure here if one can work out the classification system. With the second kind of valued OTL, it is the direct effect of OTL on the gatekeeper idea/concept/strategy on the ability/achievement components that

should be detected. There are obviously limits to the reliability of single-item OTL measures, but unless the assessment multiply samples the same idea/concept/strategy, there aren't other good choices.

One possible implication of the above is that item level OTL effects on item parameters (from a Muthén-type IRT model) are likely to be generally useful at some stage to detect whether we have removed item-specific components of performance that are irrelevant to the traits of interest or whether we have adequately modelled all the traits of interest. If a cluster of "similar" items have strong effects, then it may be because of failure to adequately model the pertinent ability/achievement components.

9. Implicit in the previous point is that except in the most narrow of achievement assessments, the psychometric model for outcomes will invariably need to incorporate multiple latent ability/achievement dimensions. Given any reasonable degree of variability in instructional practices and their effectiveness, one would want to detect the specific performance dimensions for which variability occurs rather than a general knowledge/ability trait.

Specific Applications of ISP Reasoning

So far I have concentrated on general thinking that motivates our work. Now I will turn briefly to a sample of the dilemmas in our actual project work. The current status of

project work in that we are engaged in the process of rethinking and elaboration of ideas related to the concept of "instructionally sensitive psychometrics". All along our belief has been that we are trying to develop assessment technicology that will be sensitive to the influences of education/schooling/instruction. The Muthén modeling methodology appears to afford the possibility of analytically elaborating IRT models to incorporate such influences. The problem was that there is literally no prior work besides Muthén's that links IRT estimation with structural equation modeling and thus no precedents for how to interpret the results from an instructional perspective.

The need for elaborating our instructional sensitivity thinking became especially clear with the results reported in the Muthén-Kao-Burstein paper. The items that prove to be instructionally sensitive as used there were primarily beginning concepts in a given content area (e.g., which of the following is an acute angle?) suggesting that gross differences in opportunity to learn a content area within the SIMS sample were being detected. On further examination, however, this interpretation was an oversimplification of the results from the analyses. What was actually occurring was that the items that were being called instructionally sensitive were those that exhibited OTL effects on the specific item, over and above the OTL effects on the latent achievement trait. But this type of direct effect on item performance levels is not necessarily good. For instance, when the student is asked the question

about acute angles, the intent is not to measure the student's knowledge of acute angles but instead to infer from his performance on this item to knowledge about the properties of triangles (the knowledge or skill subdomain). If the correct response were given simply because the teacher taught the acute angle concept because it specifically appears on the test, then the instructional sensitivity is not to the domain but to the item. This form of sensitivity from our view is much like item bias. Once exposed, everyone does well on the item; in the absence of exposure, the unexposed group does worse not because they are less capable but because they were never introduced to the concept.

Our current thinking on the matters raised in the previous paragraph is that we need to refine and clarify our conception of instructional sensitivity, on the one hand, and think more carefully about the adequacy of achievement trait modeling, on the other. For instance, if there were separate achievement traits for introductory concepts and more advanced mathematics built into the model, we might expect that the direct effects of item-level OTL on item-specific performance might decline for the concept items while these effects would be manifested on the introductory concepts trait. If so, then one would interpret the model to be instructionally sensitive to weak programs that simply don't cover sufficient content rather than to direct teaching to the items on the test. Eventually, we expect that our elaboration and extension of our conception of instructional sensitivity will lead to a conceptual piece (in addition to the

technical work in the Muthén papers, but perhaps drawing on examples from that work for illustrative purposes) intended for the broader educational research and measurement community to stimulate dialogue about the current state of instructional assessment. Right now, the collaboration developing around this work seems quite promising and important.

A major activity has been factor analysis of these same SIMS items. This has been a joint effort including both substantive and more psychometric aspects (see discussion above). In terms of psychometric work, the factor analysis modeling has involved determination of appropriate ways to formulate and analyze a set of items where one dominant factor is present--a general mathematics achievement trait. The aim of the analysis is to try to isolate specific factors corresponding to more narrowly defined sets of items. Regular exploratory analysis cannot find such factors due to the dominance of the general factor. Instead a confirmatory factor analysis structure has to be defined from substantive reasoning and then tested out on the data. The specific psychometric considerations in our case involves the use of tetrachoric correlations for dichotomous variables, the analysis of a set of items that haven't all been administered to all students (rotated form--missing data issue), and how to best utilize the teacher-reported opportunity to learn information in the analysis.

In other words, we are trying to develop more sophisticated conceptions of the impact of heterogeneous learning environments

(what we mean in part by instructional sensitivity) on performance and operationalize these conceptions in various ways within the psychometric modelling. At the same time, we have already moved away from trying to fit a unidimensional achievement trait within the model by adapting Gustafsson's strategies for hierarchical modelling of general and specific abilities. A considerable portion of the empirical work on SIMS data has been toward developing a conceptually appropriate and empirically adequate multidimensional model for the SIMS items as a first step toward incorporating a multidimensional latent trait model within the overall analytical scheme. This is not a typical IRT model nor is Muthén's approach like other efforts to develop multidimensional IRT models. It is simply too early to tell how far we can go with this effort but in our view, it is clearly worth doing.

References

Airasian, & Madaus, (1983)

Baker, E.L. (1987)

Baker, E.L., & Herman, J.L. (1986). Educational evaluation: Emergent needs for research. Evaluation Comment, Vol 7, no. 2. UCLA Center for the Study of Evaluation.

Bejar, I.I. (1984). Educational diagnostic assessment. Journal of Educational Measurement, 21, 175-189.

Burstein, L. (1980). The role of levels of analysis in the specification of educational effects. In R. Dreeben & J.A. Thomas (Eds.), Analysis of Educational Productivity. Vol. I: Issues in Microanalysis. Cambridge, MA: Ballinger.

Burstein, L. (1983).

Burstein, L. (1984). Information use in local school improvement: A multilevel perspective. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

Burstein, L. (1986).

Burstein, L., et al (In press). Second International Mathematics Study Volume 3: Student growth and classroom processes in lower secondary schools. London, England: Pergamon Press.

Burstein, L., Chen, Z., Sen, Q., & Kim, K.S. (1987). Empirical properties of mathematics bridging tests: Bridging secondary-postsecondary mathematics study. Los Angeles: UCLA Center for the Study of Evaluation.

Burstein, L., Webb, N.M., , Muthén, B.O., & Linn, R. (1987). Expanding the mathematic assessment portfolio. Testing what and how students are taught and what they understand as well as what they know. Paper presented at the National Academy of Science.

Cooley, W.W., & Leinhardt, G. (1980) The instructional dimensions study. Educational Evaluation and Policy Analysis.

Delandshere, J. (In press)

Glaser, R. (1986) The integration of instruction and testing. In the proceedings of the 1985 ETS Invitational Conference: The redesign of testing for the 21st century. Princeton, NJ: Educational Testing Service.

Kifer, E., Schmidt, W., & Wolfe, R. (1984) Cognitive growth in eight countries: Lower secondary school. Washington, DC: National Center for Education Statistics.

Leinhardt, G. (1983). Overlap: Testing whether it's taught. In G.F. Madaus (Ed.) The Courts, Validity, and Minimum Competency Testing. Hignham, MA: Kluwer-Nijhoff Publishing.

Leinhardt, G., & Seewald, A.M. (1981). Overlap: What's tested, what's taught. Journal of Educational Measurement, 18, 85-96.

Linn, R.L., (1986) Barriers to new test design. The redesign of testing for the 21st century: Proceeding of the 1985 ETS Invitational Conference. Princeton, NJ: Educational Testing Service

Linn, R.L., (1987). Accountability: The comparison of education systems. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

Linn, R.L. (1988)

McKnight, C.C., Crosswhite, F.J., Dossey, J.A., Kifer, E., Swafford, J.O., Travers, K.J., & Cooney, T.J. (1987). The underachieving curriculum: Assessing U.S. school mathematics from an international perspective. Champaign, IL: Stipes.

Muthén, B.O., Kao, C-F, & Burstein, L. (1987). Instructional sensitivity in mathematics achievement test items: Application of a new IRT-based detection technique. Los Angeles, UCLA Center for the study of Evalution.

Petrie, H.G. (1987) Introduction to "Evaluation and testing". Educational Policy, 1, 175-180.

Pipho, C. (1985) Tracking the reforms, Part 5: Testing--Can it measure the success of the reform movement. Education Week, p.19.

Robitaille, D., & Garden, R. (1988). Second International Mathematics Study, Volume 2: Contexts and outcomes of school mathematics. London, England: Pergamon Press.

Shavelson, R.J., Webb, N.M., & Burstein, L. (1986). The measurement of teaching. In M.C. Wittrock (Ed.) Handbook for Research on Teaching. (3rd Edition), New York: Macmillan 50-91.

Shavelson, R.J., Webb, N.M., Shemesh, M. & Yang, J-W. (1988) Translation among symbolic representations in problem-solving. Los Angeles: UCLA Center for the Study of Evaluation.

Sirotnik, K.A., & Burstein, L. (1986). Making sense out of comprehensive school-based information systems: an exploratory investigation. Los Angeles: UCLA Center for the Study of Evaluation.

Travers, K.J., & Westbury, I. (1989). Second International Mathematics Study Volume 1: international analysis of mathematics curricula. London, England: Pergamon Press.

Webb, N.M., & Shavelson, R.J. (1988)

Wolfe, R.G. (1986)